DOCUMENT RESUME

ED 265 037 SE 046 337

AUTHOR Dean, Robert B., Ed.
TITLE Training of Sanitary Engineers in Europe.
INSTITUTION World Health Organization, Copenhagen (Denmark). Regional Office for Europe.
REPORT NO ICP/EHP 002; ISBN-92-890-1022-3
PUB DATE 85
NOTE 202p.
AVAILABLE FROM WHO Publications Center USA, 49 Sheridan Ave., Albany, NY 12210.
PUB TYPE Reports - Descriptive (141)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Degree Requirements; Developing Nations; *Engineering; *Engineering Education; Foreign Countries; Paraprofessional Personnel; Postsecondary Education; *Program Content; Program Descriptions; *Public Health; Science Education; *Training; Water Quality
IDENTIFIERS *Europe; *Sanitary Engineering

ABSTRACT

Sanitary engineering (also known as public health engineering in the United States) covers all fields where engineering activities are more efficient than medical action for dealing with public health concerns. This book focuses on the training of individuals for these fields. Part I provides information on the general organization of training in sanitary engineering in 33 countries, as well as details of institutions that teach sanitary engineering as an integral part of public health and organize postgraduate specialization courses or courses in foreign languages for students from other countries. Part II lists and briefly describes a number of international organizations that are concerned with the training and qualifications of engineers and technicians, including sanitary and public health engineers. Fifteen selected programs (specifying those that cater particularly for developing nations) in countries of the European region and three representative programs of institutions in the United States are described in detail in part III. The countries are Algeria, Czechoslovakia, France, Federal Republic of Germany, Hungary, Italy, Morocco, Netherlands, Portugal, Switzerland, Turkey, and the United Kingdom. Part IV is a report of a World Health Organization meeting titled "Consultation on the Public Health Component of Sanitary Engineers' Training Curricula." (JN)

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World Health Organization
Regional Office for Europe
Copenhagen

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Training of sanitary engineers in Europe

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The World Health Organization is a specialized agency of the United Nations with primary responsibility for international health matters and public health. Through this Organization, which was created in 1948, the health professions of some 160 countries exchange their knowledge and experience with the aim of making possible the attainment by all citizens of the world by the year 2000 of a level of health that will permit them to lead a socially and economically productive life.

The WHO Regional Office for Europe is one of six regional offices throughout the world, each with its own programme geared to the particular health problems of the countries it serves. The European Region has 33 active Member States,[a] and is unique in that a large proportion of them are industrialized countries with highly advanced medical services. The European programme therefore differs from those of other regions in concentrating on the problems associated with industrial society. In its strategy for attaining the goal of "health for all by the year 2000" the Regional Office is arranging its activities in three main areas: promotion of lifestyles conducive to health; reduction of preventable conditions; and provision of care that is adequate, accessible and acceptable to all.

The Region is also characterized by the large number of languages spoken by its peoples, and the resulting difficulties in disseminating information to all who may need it. The Regional Office publishes in four languages — English, French, German and Russian — and applications for rights of translation into other languages are most welcome.

[a] Albania, Austria, Belgium, Bulgaria, Czechoslovakia, Denmark, Finland, France, German Democratic Republic, Federal Republic of Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, Morocco, Netherlands, Norway, Poland, Portugal, Romania, San Marino, Spain, Sweden, Switzerland, Turkey, USSR, United Kingdom and Yugoslavia.

World Health Organization
Regional Office for Europe
Copenhagen

Training of sanitary engineers in Europe

Edited by

Robert B. Dean
Consultant, Promotion of Environmental Health
WHO Regional Office for Europe

ICP/EHP 002

This publication is dedicated to the memory of the late Dr Carmine Ferullo, until 1980 in charge of the environmental health manpower development subprogramme of the WHO Regional Office for Europe. His wide-ranging knowledge and experience, together with his quiet enthusiasm in promoting the objectives of WHO, won him the esteem and affection of colleagues both within the Organization and in many countries of the European Region.

ISBN 92 890 1022 3

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The views expressed in this publication are those of the author and do not necessarily represent the decisions or the stated policy of the World Health Organization.

PRINTED IN DENMARK

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Foreword

Environmental health has been defined by the World Health Organization as the control of all those factors in the physical environment that exercise or may exercise a deleterious effect on physical development, health or survival. This far-reaching definition encompasses a very wide range of activities in many different disciplines, and the method by which the appropriate services are organized will depend in part on the system of government of the country concerned.

This publication is the outcome of a survey within the WHO European Region of institutions and facilities for the training of engineers capable of carrying out control measures for the improvement of human health. Such engineers are usually known as sanitary engineers or public health engineers.

The supply of properly trained local engineers, especially those with an adequate understanding of public health problems, is limited in many countries of the Region. It is one of the aims of WHO to encourage the development of suitable training facilities throughout the Region so that qualified engineers will be available to perform those tasks which can lead to an improvement in the health of the population, i.e. the provision of better water, adequate sanitation, cleaner air and so on.

In order to assess the availability of sanitary engineers in Member States of the European Region, various surveys and reports have been prepared over the past years. The present work includes the report on a Consultation on the public health component of sanitary engineers' training curricula, held in Copenhagen from 8 to 10 November 1982 (see part IV). The meeting recommended that a directory of institutions offering training in sanitary engineering be prepared. This directory is presented in part I, which consists of 33 short reviews giving, for each Member State[a] in the Region, information on the general organization of training in sanitary engineering, as well as details of institutions that teach sanitary engineering as an integral part of public health and organize post-graduate specialization courses or courses in foreign languages for students

[a] *This book was prepared when Algeria was a member of the WHO European Region. In accordance with resolution WHA37.12 of 14 May 1984, Algeria is now a member of the African Region of WHO.*

from other countries. Fifteen selected programmes in countries of the European Region and three representative programmes of institutions in the USA are described in more detail in Part III. The information has been compiled on the basis of WHO records, the knowledge of WHO officers and consultants, direct contacts with universities and technical institutes and, in certain cases, questionnaires. A historical survey of the development of sanitary engineering and the training and tasks of sanitary engineers forms part of the report on the Consultation.

The terms "sanitary engineer" and "public health engineer" are essentially equivalent, the differences on the two sides of the Atlantic being only historical ones. The current scope of sanitary engineering is covered in the conclusions of the report on the Consultation (see page 168). An attempt has been made to concentrate on those courses that have components directly related to human health, while less attention has been paid to general courses on ecological relations between species. The emphasis is thus on public health rather than on environmental engineering, although the latter term can cover most of the material that the Consultation members considered to be important. Programmes in molecular biology engineering, medical engineering, and the production of prosthetics and surgical devices are specifically omitted.

There are two basic methods of training sanitary engineers. Undergraduate training usually takes place in a school of civil engineering, where courses in aspects of engineering related to public health are offered, usually as an option, in the final year or two of the programme. Postgraduate training takes many forms, ranging from a one-year university programme of studies for a diploma or Master's degree to a series of special short courses in a continuing education programme sponsored by a professional association. A few programmes are specifically designed for foreign students, the courses being offered in one of the major world languages. In most cases, however, instruction is given in the local language and foreign students may have to demonstrate competence in that language before they are admitted to the course.

The survey shows that there is no universally applicable method of training sanitary engineers; if it is to be effective, a system must conform with the basic educational and legislative principles of the country concerned. Some systems may be better than others, and all seem to be capable of improvement.

This publication is the third in a series of surveys of services in the European Region. The first, Food safety services *(Public Health in Europe, No. 14), was published in 1981. The second,* Environmental health services *(Public Health in Europe, No. 19), was published in 1983. Further surveys in preparation cover water services and occupational health services. Surveys of chemical safety in Europe are contained in the Health Aspects of Chemical Safety series:* Emergency response to chemical accidents *(Interim document No. 5). Another survey due to appear in this series is on programmes and courses in toxicology in Europe.*

The Regional Office would appreciate receiving criticism and comments on this publication from readers, with a view to the preparation of an updated second edition. Correspondence should be addressed to: Director, Environmental Health Service, WHO Regional Office for Europe, Scherfigsvej 8, 2100 Copenhagen Ø, Denmark.

Introduction

Historical Background

The concept of sanitary engineering originates in the USA. At the beginning of the twentieth century, the need for engineers with technical expertise in the area of public health arose in the Caribbean region. This expertise was needed to help control disease vectors such as *Aedes* or *Anopheles* mosquitoes, to produce safe drinking-water and to ensure the hygienic disposal of human excreta. Later, the field of sanitary engineering was broadened to include, for example, the disposal of urban and industrial liquid and solid wastes, air pollution control, housing hygiene, and noise and radiation monitoring. In Europe, the United Kingdom as early as the end of the nineteenth century developed the idea of the public health engineer as someone specialized in drinking-water supply, sewerage and sewage treatment, but in most European countries the concept of sanitary engineer was unknown before the creation of WHO. However, prior to this time, the duties performed by sanitary engineers in the USA were being performed by other kinds of engineer in European countries.

WHO Activities to Promote the Sanitary Engineering Concept in Europe

As soon as the WHO Regional Office for Europe was established it began to promote the concept of sanitary engineering among Member States, i.e. to stress the public health approach to sanitary engineering instead of the civil engineering approach. The definition of sanitary engineering as an activity that "covers all technical fields where engineering activities are more efficient than medical action to settle public health problems" was developed in the 1950s to explain the public health approach at a time when the civil engineering approach to sanitary engineering covered only water supply technology, drinking-water treatment technology, and sewerage and sewage treatment technology. With minor changes in language, this definition is still a guiding factor in the programme.

In most western European countries, civil engineers have been in charge of water supply and sewerage activities; thus, one way to create sanitary

engineering courses was to introduce a strong public health component into training curricular for civil engineering. In most eastern European countries, environmental health activities were managed not by engineers but by public health officers with medical and community hygiene training; thus WHO encouraged closer collaboration in these countries between communal civil engineers and physicians in charge of community hygiene. Finally, in some developing countries of the Mediterranean area, there was a lack of engineering training curricula; here WHO promoted the development of sanitary engineering courses designed in accordance with the public health approach and assisted in the strengthening of such courses.

While waiting for these actions to produce results, the WHO Regional Office for Europe during the 1970s also encouraged and supported international sanitary engineering curricula in three of its working languages, i.e. in Russian (Warsaw, Poland), in English (Delft, Netherlands) and in French (Lausanne, Switzerland, and Rabat, Morocco). Today, sanitary engineering curricula with a public health orientation have been established in most European countries. The need for international curricula in the European Region is therefore decreasing, but the courses in Delft, Lausanne and Rabat remain extremely useful at the interregional and global levels, and are attended each year by a significant number of foreign students and WHO fellows from non-European countries.

Although WHO has made significant progress in promoting the concept of sanitary engineering in Europe, the results obtained to date are still tenuous. In some cases there is a tendency at the university level to forget the public health approach in sanitary engineering and to revert to the traditional civil engineering approach. Another tendency is to emphasize the ecological rather than the public health approach and to turn sanitary engineering curricula into environmental engineering curricula. The participants of the Consultation on the public health component of sanitary engineers' training curricula, held in Copenhagen in 1982, recommended that "international recognition should be accorded only to those sanitary (or public health) engineering courses in Europe which stress public health in their curriculum" (see part IV). Therefore, in order to strengthen the public health component of the training curricula for sanitary engineering courses, those courses which fail to include sufficient public health training should no longer be called sanitary engineering courses.

It is important to point out that, in WHO's Seventh General Programme of Work covering the period 1984–1989, the two main priorities of the health manpower development programme, which also includes environmental health development, are:

(*a*) the continuing education of health personnel; and

(*b*) strengthening the training of intermediate health personnel.

Applied to the environmental health sector, these priorities will be:

(*a*) the continuing education of sanitary engineers and environmental health scientists; and

(*b*) strengthening of training institutions for environmental health officers and for water supply and wastes disposal operators or supervisors.

Thus, during the 1980s, WHO's cooperation with sanitary engineering training institutions in the European Region will be directed towards the continuing education of sanitary engineers and will be restricted to institutions applying the public health approach to sanitary engineering.

Background and Objectives of the Consultation

In 1956, WHO headquarters in Geneva published a monograph by Professor M. Petrik entitled "The training of sanitary engineers: schools and programmes in Europe and in the United States".[a] This monograph shows clearly the lack of true sanitary engineering courses in Europe at that time. It is now completely out of date and needs to be replaced. Updated directories of sanitary engineering courses existing in Canada and the USA have already been produced.[b] For its part, the WHO Regional Office for Europe has undertaken a study on the availability and content of training courses for environmental specialists (project ICP/EHP 002), the main target of which was to produce a directory of sanitary engineering courses available in countries of the WHO European Region. This directory is contained in parts I and III of the present publication.

In 1967, WHO headquarters published a technical report, "The education of engineers in environmental health",[c] prepared by an Expert Committee, of which two of the participants of the 1982 Consultation in Copenhagen, namely Professor Ives and Professor Mendia, had been members. This report emphasized the broadening scope of environmental health in an increasingly industrialized society. It did not include a specific chapter devoted to the public health component of a sanitary engineering training curriculum, but the subject was touched upon. However, recommendation 7 of the 1967 Expert Committee stresses the need for an international directory of institutions and thus justifies project ICP/EHP 002.

A Regional Office report of 1973, "Study on manpower requirements in environmental health,[d] indicates the views of European governments at that time concerning the role and training of sanitary engineers and other environmental health personnel; it states clearly the policy of the Regional

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[a] **Petrik, M.** *The training of sanitary engineers: schools and programmes in Europe and in the United States.* Geneva, World Health Organization, 1956 (WHO Monograph Series, No. 32).

[b] **Vesilind, P.A. & Minear, R.A.** *Register of environmental engineering graduate programs.* Association of Environmental Engineering Professors. Woburn, MA, Ann Arbor Science Publishers, 1981.

[c] WHO Technical Report Series, No. 376, 1967 (*The education of engineers in environmental health:* report of a WHO Expert Committee).

[d] *Study on manpower requirements in environmental health:* report of a Steering Committee. Copenhagen, WHO Regional Office for Europe, 1973 (document EURO 3006).

Office in the field of environmental health manpower development during the 1970s. In 1979 a study led to the publication of "The environmental health officer in an industrial society",[a] of which chapters 4 and 5 and Annex II are of particular relevance to the present work.

Two working papers, prepared by Professor Ives and Professor Hilbert for use at the 1982 Consultation, describe the concept of public health engineer in the United Kingdom and that of sanitary engineer in the USA (see part IV, appendixes 1 and 2).

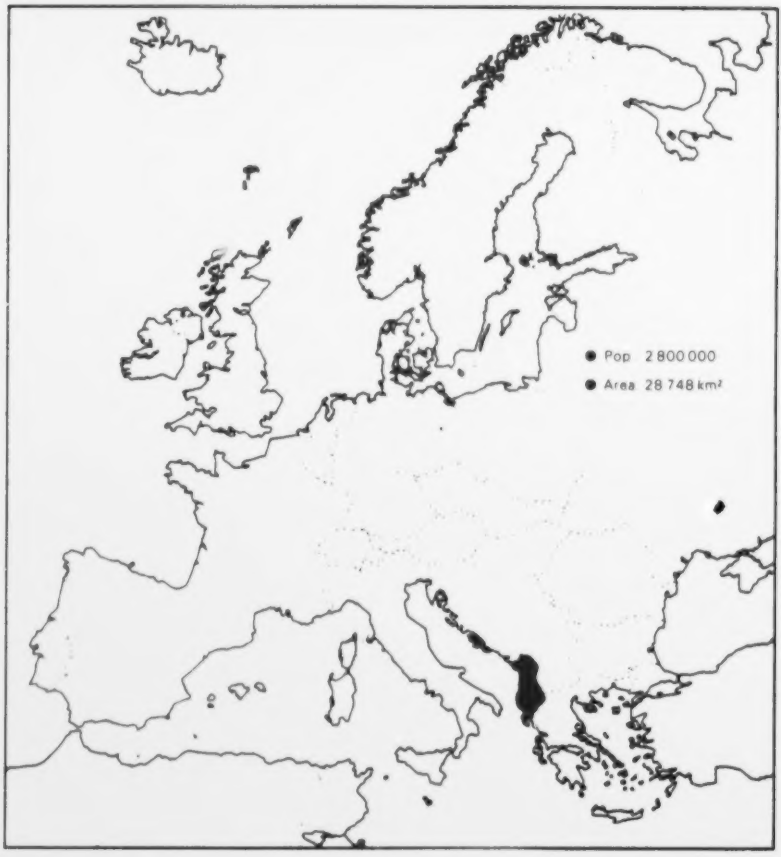
The first objective of the Consultation was to update and complement the 1967 technical report referred to above, by stressing the importance of the public health orientation in sanitary engineering in Europe, and by giving detailed recommendations related to the public health, biological, microbiological and possibly medical components of the training curricula of sanitary engineers, especially those trained to work in the public health services.

Current WHO policy is summarized by the slogan "Health for all by the year 2000", the practical content of which is described in the "Regional strategy for attaining health for all by the year 2000",[b] endorsed by the Regional Committee for Europe at its thirtieth session. This is now the Regional Office's major policy document, and the sanitary engineers discussed here are those whom the public health services require to contribute to the "reduction of preventable conditions" described in that document.

[a] *The environmental health officer in an industrial society:* report on a WHO Consultation. Copenhagen, WHO Regional Office for Europe, 1980 (EURO Reports and Studies, No. 29).

[b] *Regional strategy for attaining health for all by the year 2000.* Copenhagen, WHO Regional Office for Europe, 1980 (unpublished document EUR/RC30/8).

I. Country reviews



Albania

The Socialist People's Republic of Albania is situated in the west of the Balkans, on the eastern shore of the Adriatic Sea. It has boundaries with Yugoslavia in the north and east and with Greece in the south-east.

Specialists in sanitary chemistry are employed in the Institute of Hygiene and Epidemiology and 26 regional directorates of hygiene and epidemiology under the Ministry of Public Health; these are specialized organizations whose duties are mainly preventive in character.

The main function of the Institute of Hygiene and Epidemiology is to conduct research and provide training in hygiene and epidemiology in collaboration with the regional directorates of hygiene and epidemiology.

5

The Laboratory for Hydraulic Research, under the Academy of Sciences, carries out complex studies in the fields of water power, irrigation, water supply and wastewater disposal.

Specialists in sanitary chemistry are taught at the University of Tirana, the country's capital.

Addresses

Ministry of Public Health
(Ministria e Shendetesise)
Tirana

Tel. 7941

University of Tirana
(Universiteti Tiranes)
Faculty of Natural Sciences
Tirana

Institute of Hygiene and Epidemiology
(Instituti Higjienes dhe Epidemiologjise)
Tirana

Academy of Sciences
(Akademia Shkencave)
Tirana

Laboratory for Hydraulic Research
(Laboratori i Kerkimeve Hidraulike)
Tirana

Algeria

The People's Democratic Republic of Algeria lies on the Mediterranean between Morocco and Tunisia and shares borders in the Sahara with the Libyan Arab Jamahiriya, Niger, Mali and Mauritania. Government services are centralized in the capital, Algiers.

The position of sanitary engineer is officially recognized in Algeria, but recruitment conditions at the health services level have still to be defined. Prior to 1981, there were no local facilities for training sanitary engineers, and those few who were available had been trained abroad.

The notion of the sanitary engineer participating in public health action was introduced in Algeria more than a decade ago by WHO, under whose

sponsorship a training programme for sanitary engineers was started in 1979. Within this framework, technical assistance was provided to Algeria.

Thanks to assistance from UNDP, the first group of Algerian sanitary engineers began specialized training in February 1981 at the National School of Engineering, which forms part of the Houari Boumedienne University of Science and Technology, Algiers. This specialized programme in sanitary engineering, consisting of the last four semesters of a ten-semester programme, leads to a state degree in sanitary engineering (see part III).

Courses of special relevance to public health include those in environmental ecology, environmental chemistry, environmental microbiology, environmental law, public health, nutrition and food safety, drinking-water supply, wastewater, solid wastes, housing hygiene and air pollution. The language of instruction is French.

The Ministry of Public Health participates in this training by supplying part-time teachers for subjects related to public health. The shortage of sanitary engineers in Algeria is acute, especially because of the increasing need to have one sanitary engineer on location in each large commune. Consequently, it is essential to secure the continuity of this training and to strengthen its quality.

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National Polytechnic of Algeria
(Ecole nationale polytechnique algérienne)
Avenue Pasteur
El Harrach — Algiers

Tel. 76 59 29, 76 53 01/02/03

Houari Boumedienne University of Science and Technology
(Université des Sciences et Techniques Houari Boumedienne)
B.P. 9
Bab-ez-Zouar — Algiers

Tel. 76 44 98

Austria

The Republic of Austria lies in a mountainous area in the centre of Europe, and is bounded by Czechoslovakia, Hungary, Yugoslavia, Italy, Switzerland and the Federal Republic of Germany. It is a federal republic made up of nine provinces (*Länder*), each possessing a high degree of autonomy. The language is German.

The position of sanitary engineer is not recognized within the administration and there is no formal training in sanitary engineering at the technical universities. Some of the training for engineers covers aspects of sanitary engineering. For example, at the University of Innsbruck there is a professorship of domestic and industrial sanitation. A WHO collaborating

centre for wastes disposal is maintained in the Faculty of Civil Engineering and Architecture at the Technical University of Vienna.

Training received in universities of the Federal Republic of Germany and Switzerland is recognized as academically equivalent to local training.

Addresses

University of Vienna
(Universität Wien)
Dr. Karl Lueger Ring 1
1010 Vienna

Faculty of Medicine:

Institute of Environmental Hygiene
(Institut für Umwelthygiene)
Kinderspitalgasse 16
1090 Vienna

Tel. 43 15 95

Faculty of Formal and Natural Sciences:

Institute of Domestic and Nutrition Sciences
(Institut für Haushalts- und Ernährungswissen-schaften)
Lammgasse 8
1080 Vienna

Tel. 42 32 97

University of Innsbruck
(Universität Innsbruck)
Inrain 52
6020 Innsbruck

Faculty of Civil Engineering and Architecture:

Institute of Communal Water Supply and Environmental Technology
(Institut für Siedlungswasserbau und Unwelttechnik)
Technikerstraße 13
6020 Innsbruck

Tel. 81 6 51

Technical University of Vienna
(Technische Universität Wien)
Karlsplatz 13
1040 Vienna

Faculty of Technology and Natural Sciences:

Institute of Food Chemistry and Food Technology
(Institut für Lebensmittelchemie und -technologie)
Getreidemarkt 9
1060 Vienna

Tel. 5601/4777

Faculty of Civil Engineering and Architecture:

Institute of Hydraulics, Hydrology and Water Management
(Institut für Hydraulik, Gewässerkunde und Wasserwirtschaft)
Karlsplatz 13
1040 Vienna

Tel. 5601/3217

Institute of Water Quality and Surface Water Technology
(Institut für Wassergüte und Landschaftswasserbau)
Karlsplatz 13
1040 Vienna

Tel. 5601/3137, 3147

Faculty of Mechanical Engineering:

Institute for Industrial and Management Sciences
(Institut für Arbeits- und Betriebswissenschaften)
Theresianumgasse 27
1040 Vienna

Tel. 658397

Technical University of Graz
(Technische Universität Graz)
Rechbauerstraße 12
8010 Graz

Faculty of Civil Engineering:

Institute of Communal and Industrial Water Management,
River Engineering and Agricultural Hydraulics
(Institut für Siedlungs- und Industriewasserwirtschaft, Flußbau und
Landwirtschaftlichen Wasserbau)
Streymayrgasse 10
8010 Graz

Tel. 7751 1/8371

Institute of Electrical and Biomedical Engineering
(Institut für Elektro- und Biomedizinische Technik)
(with experimental and testing centre for biomedical engineering)
Infeldgasse 18
8010 Graz

Tel. 7751 1/7391

Faculty of Technology and Natural Sciences:

Institute of Biotechnology, Microbiology and Wastes Technology
(Institut für Biotechnologie, Mikrobiologie und Abfalltechnologie)

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Institute of Water Management
(Institut für Wasserwirtschaft)
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Belgium

The Kingdom of Belgium lies on the North Sea between France and the Netherlands. The country contains two major language groups, the Flemish (Dutch-speaking) and the Walloons (French-speaking). Government services are in the process of being regionalized along essentially linguistic lines. Academic institutions provide instruction exclusively in one or other of the two languages.

The post of sanitary engineer is not formally recognized in the administration, although the Ministry of Public Health and Family Affairs and the Ministry of Public Works have environmental health and town planning units which employ engineers specialized in these fields.

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For several decades the independent, nonprofit-making Belgian Centre *for Environmental Studies and Documentation (Centre belge d'Etude et de* Documentation de l'Environnement) has been carrying out very effective applied research in the area of water resources in relation to public health, and also maintains a WHO collaborating centre for wastes disposal.

Training in engineering is provided at four universities: Ghent, Liège, Antwerp and Brussels. There are no formal courses in sanitary engineering at the undergraduate level, although some aspects of the subject are dealt with in more general courses.

At the postgraduate level, the Faculty of Applied Sciences (School of Engineering) at the University of Liège offers a one-year postgraduate course leading to a diploma in engineering (town planning). This programme is open to candidates who have obtained a diploma in civil engineering (building) or civil engineering (architecture). Although this course does not train sanitary engineers as such, the curriculum includes several traditional environmental health subjects, i.e. town planning, sanitary engineering (including water and waste treatment), general hygiene, tropical hygiene (including aspects of entomology and parasitology), hydrogeology, and civil engineering (urban).

The Interfaculty Centre for the Study of Air, Soil and Water Pollution at the University of Ghent offers postgraduate studies in the environmental and health aspects of sanitary engineering. The Institute for Developing Countries at the Antwerp State University Centre provides specialized training in environmental subjects for students from developing countries. English may be used in some of the lectures.

Both the Free University of Brussels and the Catholic University of Louvain offer courses in biomedical engineering in the Dutch language. The programme at Louvain includes public health studies, but the emphasis at both universities is on applications of engineering to medical treatment.

Addresses

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(Rijksuniversiteit te Gent)
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25 St.-Pietersnieuwstraat
Ghent

Tel. 23 38 21

State control. Language of instruction: Dutch

Interfaculty Centre for the Study of Air, Soil and Water Pollution
(Interfacultair Centrum voor de Studie van Lucht-, Bodem- en Waterverontreiniging)
533 Coupure Links
Ghent

University of Liège
(Université de Liège)
Faculty of Applied Sciences
7 place du 20 août
4000 Liège

Tel. 42 00 80

State control. Language of instruction: French

Belgian Centre for Environmental Studies and Documentation
(Centre belge d'Etude et de Documentation de l'Environnement)
2 rue Armand St. Evart
4000 Liège

Tel. 52 12 33

Antwerp State University Centre
(Rijksuniversitair Centrum te Antwerpen)
Faculty of Sciences
Kasteel "Den Brandt"
12 Beukenlaan
2020 Antwerp

Tel. (03) 27 38 07

State control. Language of instruction: Dutch

Institute for Developing Countries
52 A. Goemaerelei
2000 Antwerp

Free University of Brussels
(Vrije Universiteit Brussel)
Faculty of Applied Sciences
2 Pleinlaan
1050 Brussels

Tel. (02) 641 21 11

Private control. Language of instruction: Dutch

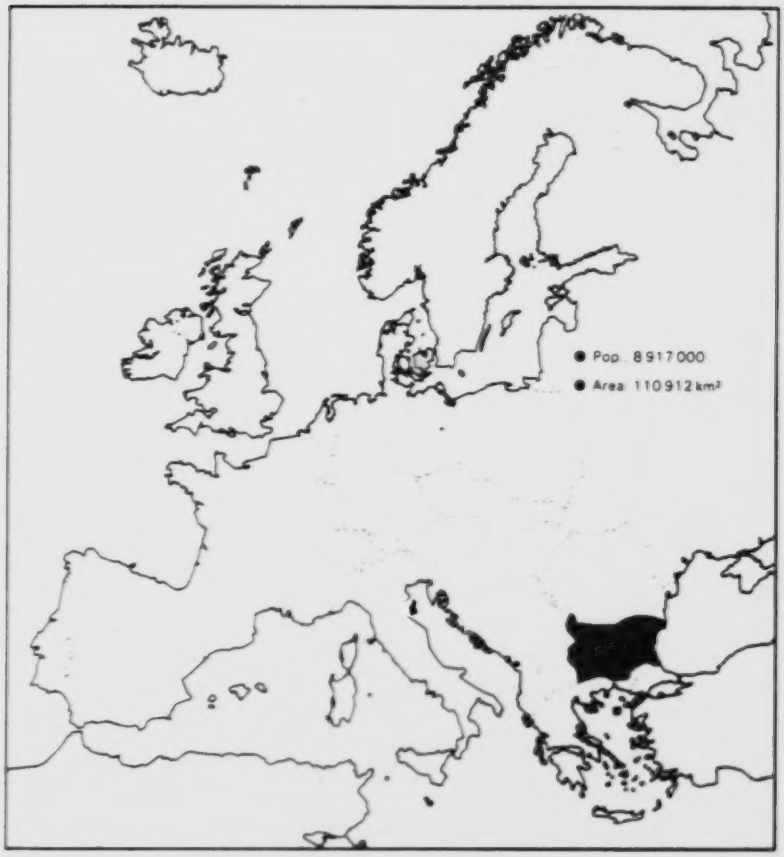
Catholic University of Louvain
(Katholieke Universiteit Leuven)
22 Naamsestraat
3000 Louvain

Tel. (016) 22 04 31

Faculty of Applied Sciences
Arenberg Kasteel
3030 Heverle

Tel. (016) 22 09 31, ext. 1350

Private control. Language of instruction: Dutch



Bulgaria

The People's Republic of Bulgaria is bounded by Romania, Yugoslavia, Greece and Turkey. To the east is the Black Sea. The Government is centralized in the capital, Sofia.

The specialist post of sanitary engineer has been recognized since 1980 within the government services. Sanitary engineers are employed in the various hygiene and epidemiological inspectorates and in the institutes of hygiene under the Ministry of Public Health and other ministries. Their tasks include sanitary control of the construction designs of new industrial, communal and other sites, the reconstruction and modernization of existing

industrial and urban designs, the implementation of new technologies, and other functions related to the application of guidelines, rules and regulations concerning health and hygiene.

The Bulgarian Academy of Sciences is responsible for ten research centres. Those dealing with aspects of sanitary engineering are: the Centre for Research in Earth Sciences, which includes a Research and Coordination Centre for the Protection and Restoration of the Natural Environment, and the Research Association on Fundamental Problems of Technical Sciences, which includes the Institute of Water Problems.

Postgraduate training for these positions is carried out after completion of basic courses in engineering at one of the higher institutes of technology, such as the Higher Institute of Architecture and Civil Engineering, Sofia. Postgraduate training is received on a part-time basis while the candidate is employed as an engineer.

The training programme takes three years, of which three months are spent at the Institute of Hygiene and Occupational Health. The individual programmes are worked out by the candidate's manager and include six preliminary oral examinations which become part of the official record. In addition to course work and examinations there is on-the-job practical training in the management aspects of the subject. During the last four months of the programme, candidates become familiar with the tasks and problems of the sanitary control services and the hygiene departments (occupational hygiene, communal hygiene, hygiene of nutrition, hygiene of children and adolescents) at the place where they are trained.

At the end of the specialization programme the candidates take a practical and theoretical examination. The examiners are a committee of three appointed by the Minister of Public Health. Candidates who pass are awarded the diploma of sanitary engineer.

Instruction is normally given in Bulgarian, but certain courses may be in Russian.

Addresses

Higher Institute of Architecture and Civil Engineering
Faculty of Civil Engineering and Faculty of Hydrotechnical Engineering
1 H. Smirnenski
Sofia

Tel. 66 17 71

Bulgarian Academy of Sciences
1, 7 Noemvri
Sofia

Tel. 8 41 41

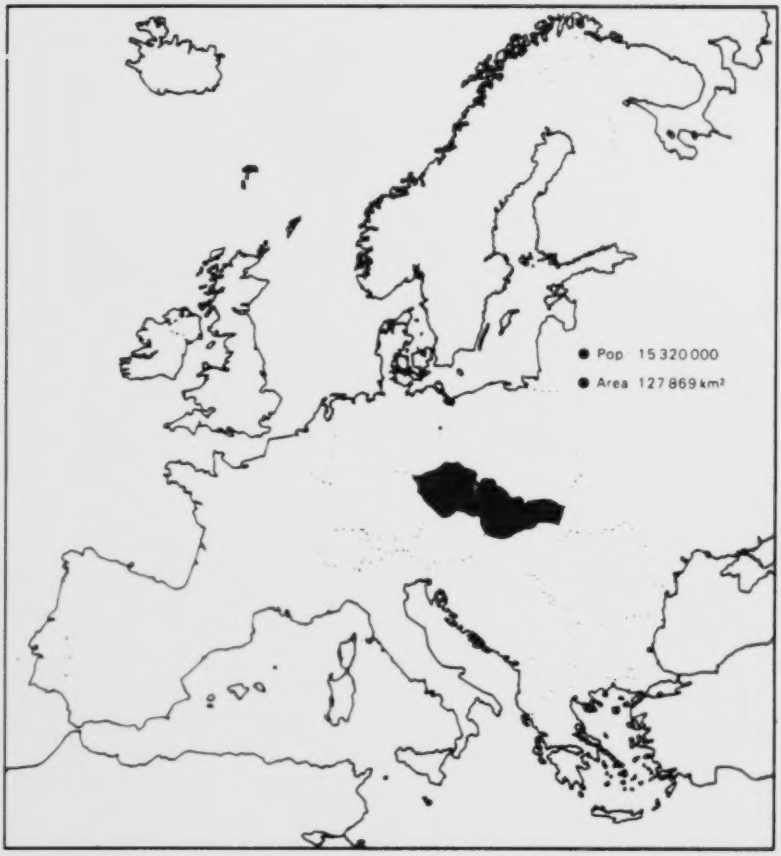
18

Ministry of Public Health
5 Lenin Square
Sofia

Tel. 86 31

Institute of Hygiene and Occupational Health
15 Dimiter Nestorov Street
Sofia

Research Institute for Labour Protection and Ergonomics
15 Dimiter Nestorov Street
Sofia



Czechoslovakia

The Czechoslovak Socialist Republic borders on the German Democratic Republic and Poland to the north, the Federal Republic of Germany to the west, Austria and Hungary to the south, and the USSR to the east. Czechoslovakia is a federal state of two republics, the Czech and Slovak Socialist Republics, each with its own government. The supreme organ of federal state power is the Federal Assembly. Each constituent republic has its own elected National Council or Parliament, which is responsible for all matters except external relations, defence, overseas trade, transport and communications.

For most services related to health and the environment there are parallel ministries in the two republics, located in Prague and Bratislava

respectively. These ministries cooperate in the issuing of regulations, which are similarly worded in the two national languages (Czech and Slovak) and are usually published simultaneously. All technical universities are under the control of the ministries of education in the respective republics.

The title of sanitary engineer is not officially recognized within the public administration framework. Nevertheless, engineers with specific experience in the field of environmental engineering and hygiene collaborate with health institutes and the national and regional hygiene and sanitation services in the programmes of environment and occupational health. Scientific training and professional activities in the field of water sciences and technology are particularly well developed.

The National Academy of the Sciences, the universities and the Ministries of Health and the Environment all offer programmes of research and training in the fields of environmental engineering, environmental sanitation, water management and technology, and the protection of workers' health.

There are three technical universities where aspects of public health are taught to engineers, namely, Bratislava (see Part III), Brno and Prague. The programme extends over five years, of which the second half is devoted to specialization. In addition, at Bratislava a three-semester programme in technology and the environment is available in the Faculty of Chemical Technology.

Postgraduate training in special subjects usually takes the form of continuing education while the engineer is employed. Programmes are developed with the advice of the employee's manager.

The Water Research Institute and the Institute of Hygiene and Epidemiology, both in Prague, provide training and research opportunities at the postgraduate level.

Addresses

Slovak Technical University of Bratislava
(Slovenska Vysoka Skola Technicka Bratislava)
Faculty of Chemical Technology and Faculty of Civil Engineering
17 Gottwaldovo Nam.
880 43 Bratislava

Tel. 566 21

Language of instruction: Slovak

Technical University of Brno
(Vysoke Uceni Technicke v Brne)
Faculty of Civil Engineering
6 Opletalova
601 90 Brno

Tel. 258 31-3

Language of instruction: Czech

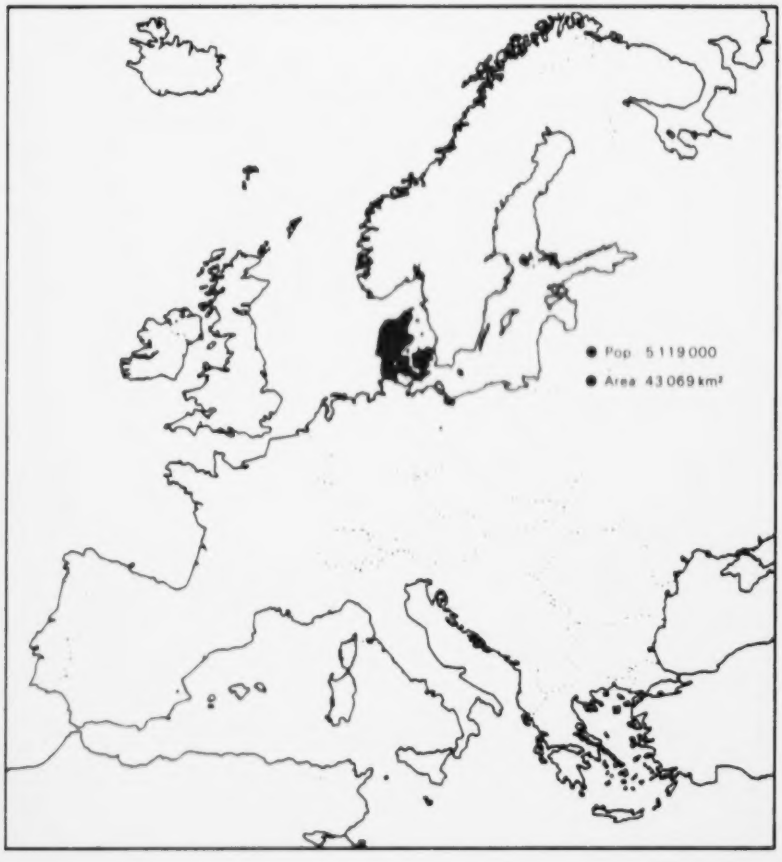
Technical University of Prague
(Ceske Vysoke Uceni Technicke v Praze)
Faculty of Civil Engineering
4 Zikova
166 35 Prague 6

Tel. 332

Language of instruction: Czech

Institute of Hygiene and Epidemiology
(Institut Hygieny a Epidemiologie)
48 Srobarova
100 42 Prague 10

Water Research Institute
(Vyzkumny Ustav Vodohospodarsky)
30 Podbabska
160 62 Prague 6



Denmark

The Kingdom of Denmark, lying between the North Sea and the Baltic Sea, comprises the peninsula of Jutland, which borders on the Federal Republic of Germany, and a large number of islands. Government services are centralized in the capital, Copenhagen, which stands on the largest island, Zealand.

Denmark is a member of the Nordic Council and academic qualifications obtained in any of the other Nordic countries (i.e. Finland, Iceland, Norway and Sweden) are recognized in Denmark. Candidates for academic positions from any of the five countries have equal status, preference being given to local candidates only if their qualifications are otherwise equivalent.

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The post of sanitary engineer is not formally recognized in the Danish governmental service, but civil engineers with training in public health are employed by the National Agency for Environmental Protection and by regional authorities, as well as in private industry. Danish engineering firms have many projects in developing countries.

Technical University of Denmark

The principal institution for the training of civil engineers is the Technical University of Denmark. Sanitary engineering is one of four programmes at the graduate level available in the Department of Environmental Engineering: the others are in wastewater treatment, water pollution, and solid wastes and soil. All four programmes include a course in environmental pollution management. Instruction is primarily in Danish, although special lectures may be given in English.

In addition to these specialized programmes, the Department of Environmental Engineering also takes Ph.D. students. A fixed programme does not exist, but a specific programme of study is designed for each student. Ph.D. studies can be arranged for foreign students also, if a subject of common interest can be agreed upon. Such studies can be in English. There is no tuition and the typical duration is 2–3 years.

The Department of Ecology and Environmental Studies offers courses which complement those provided by the Department of Environmental Engineering.

University of Aalborg

The Environmental Engineering Laboratory at the Department of Civil Engineering offers degrees at three levels, i.e. B.Sc. after 3½ years of study, M.Sc. after 5 years and Ph.D. after a further 3 years (approximately). Teaching is in Danish. At the Ph.D. level studies may be in English.

Specialization in environmental engineering starts after one year of study. The education programme includes courses and project work on sanitary and environmental topics such as water supply; sewerage; municipal and industrial wastewater treatment; aquatic ecology; fresh and marine receiving waters; sludge and solid wastes collection, treatment and recycling; air pollution; terrestrial ecology; and land disposal.

Individual guest programmes of study may be established at the M.Sc. or Ph.D. levels by special agreement with the University and the Department.

Major areas of research include phosphorus in marine sediments and sludge; urban run-off influence on small rivers; utilization of municipal sludge; and stack emissions from municipal incinerators.

University of Aarhus

The Institute of Hygiene at the University of Aarhus maintains a WHO collaborating centre on the health aspects of drinking-water.

Provision for foreign students

Postgraduate studies for foreign students can be arranged for periods of some months up to 1–2 years. Common agreement between the student and

the department regarding the subject must be obtained before the start of the study. In special cases it is possible to carry out a part of a Ph.D. study in Denmark and the other part at another (foreign) university.

Foreign students enrolled at a university abroad may apply for admission as guest students. This arrangement is for foreign students studying at a fairly advanced level in their own country who wish to take a few courses at a Danish university. Subsistence aid is available through DANIDA at the Ministry of Foreign Affairs. The study programme of a guest student is individually arranged, and the student is able to obtain attestation of the courses attended and the tests or examinations taken. Some knowledge of Danish is usually necessary, but guest students are not generally required to furnish documentary proof of a working knowledge of Danish.

Addresses

Technical University of Denmark
(Den Polytekniske Læreanstalt,
Danmarks Tekniske Højskole)
Building 101
2800 Lyngby

Tel. (02) 88 22 22

Department of Environmental Engineering
Building 115

Department of Ecology and Environmental Studies
Building 224

University of Aalborg
(Aalborg Universitetscenter)
P.O. Box 159
2 Langagervej
9000 Aalborg

Tel. (08) 15 91 11

Department of Civil Engineering
Environmental Engineering Laboratory

Tel. (08) 14 23 24

University of Aarhus
(Aarhus Universitet)
Institute of Hygiene
Ndr. Ringgade
8000 Aarhus C

Tel. (06) 13 43 11

Water Quality Institute
(Vandkvalitetsinstitut (VKI))
11 Agern Allé
2970 Hørsholm
Tel. (02) 86 52 11

Finland

The Republic of Finland, on the Baltic Sea, has borders with Sweden to the west, Norway to the north, and the USSR to the east. The principal services of the Government are centered in the capital Helsinki.

Finland is a member of the Nordic Council and academic qualifications obtained in any of the other Nordic countries (i.e. Denmark, Iceland, Norway and Sweden) are recognized in Finland. Candidates for academic positions from any of the five countries have equal status, preference being given to local candidates only if their qualifications are otherwise equivalent.

There is no exact equivalent to the degree of sanitary engineer or public health engineer in Finland. Civil engineers with training in the health aspects of their profession find employment both in government institutions and in private companies.

There are three major institutions for the training of engineers in Finland: Helsinki University of Technology; the University of Oulu; and Tampere University of Technology.

The programme of education for engineers requires 4 years of university training plus 16 weeks of industrial practice. Postgraduate training in special areas such as public health is available at Helsinki University of Technology and at the Research Institute of Public Health, Kuopio University.

All the institutions listed below are under state control, and the main language of instruction is Finnish, although some lectures may be given in Swedish.

Addresses

Helsinki University of Technology
(Teknillinen Korkeakoulu)
Department of Civil Engineering
02150 Espoo 15

Tel. 460144

University of Oulu
(Oulun Yliopisto)
Faculty of Technology
Kirkkokatu 11A, PL 191
90101 Oulu 10

Tel. 358812227 00

Tampere University of Technology
(Tampereen Teknillinen Korkeakoulu)
Department of Civil Engineering
P.O. Box 527
33101 Tampere 10

Tel. 931 16 21 22

University of Kuopio
(Kuopion Korkeakoulu)
Research Institute of Public Health
P.O. Box 138
70101 Kuopio 10

Tel. 971 16 22 11

France

The French Republic is situated in western Europe, with coastlines on the North Sea, the English Channel, the Atlantic Ocean and the Mediterranean Sea. It is bordered to the north by Belgium and Luxembourg, to the east by the Federal Republic of Germany, Switzerland and Italy, and to the south-west by Spain. Corsica, which is part of metropolitan France, lies to the south.

The position of sanitary engineer exists at present only within the health ministry and its external services, directorates of sanitary and social affairs in the regions and *départements*. At the *département* level the sanitary engineer is most frequently responsible for environmental health activities

under the chief medical officer and he collaborates with the medical officer in charge of child health. At the regional level his function is the coordination of studies and the centralization of information; he also organizes training for the personnel of the environmental hygiene services. Furthermore, the recruitment of sanitary engineers is planned to ensure the coordination of activities involving water in the major river basins. All sanitary engineers have received training at the National School of Public Health (ENSP), Rennes.

The concept of the sanitary engineer as one who contributes to public health has only recently been introduced in France. At the municipal level, the engineers responsible for the planning and installation of sanitary works refer to themselves as *hygiénistes et techniciens municipaux* in accordance with the designation adopted by their professional association. The present tendency is to use the title of *ingénieur sanitaire* for engineers who carry out environmental health work within public health services; this usage may soon be confirmed by statute. As a result of this restrictive use of the title of sanitary engineer, most engineers working in the fields of water supply and sanitation have been trained as civil or hydraulic engineers, while most of those engaged in pollution control are chemical or industrial (mining) engineers.

The function of the sanitary engineer in France is definitely not that of designing and installing public works; it is mainly one of inspecting, controlling, planning and proposing actions in the different areas of environmental hygiene with the aim of protecting and promoting the health of the population.

This orientation also includes the tasks of evaluating the programmes of action undertaken and informing professionals, political representatives and the public, as well as the other health officers concerned; the sanitary engineer is therefore clearly involved in health promotion.

To an increasing extent, the sanitary engineer has to analyse the impact of environmental hygiene on public health, and to evaluate the systems that are or should be installed, in close collaboration with the representatives of other disciplines working in the field of public health. This implies a sufficient training in public health, notably in epidemiology, to allow him to undertake actions on a multidisciplinary basis. The study programmes of the ENSP are to be modified in this direction, and training in health education will also be developed.

In general, the sanitary engineer's function is wider than that exercised by other graduates from the ENSP, who have hitherto been employed by:

— the ministry in charge of the environment and related public institutions (financial, agencies of river basins, agency of solid wastes, agency of air quality, etc.);

— public and private consulting engineers working in the field of the environment;

— hospitals;

— municipal services;

— specialized international organizations (EEC, FAO, UNEP, UNESCO, UNICEF);

— bilateral assistance programmes for developing countries.

Several institutes, schools and universities provide education in sanitary engineering science and technology, but only the ENSP awards a diploma of sanitary engineer (see Part III), and this only since 1973. However, the training of sanitary engineers was organized there as early as 1962. Thus, when in 1972 the health ministry created posts for sanitary engineers within the central administration and the external services, it was able to recruit persons who had already completed courses at ENSP.

Not every student who follows the courses at ENSP obtains the diploma of sanitary engineer. Training at ENSP is regarded as a postgraduate specialization; thus, only those students who have already graduated from other schools of engineering prior to their admission to the School obtain the diploma of sanitary engineer. For example, third-year undergraduate students at the National School of Rural Engineering and Sanitary Technology, Strasbourg (ENITRTS), or at the National School of Civil Engineering, Vaux-en-Velin (ENTPE), who attend courses in sanitary engineering at ENSP, obtain only the diploma of their first school, endorsed "sanitary engineer".

Other schools and technical institutes have established programmes in the field of environmental hygiene, but their programmes correspond only partially to the sanitary engineering programme at ENSP. They deal rather with the science and technology of water supply and sanitation. The training at ENSP is far wider in scope and gives special emphasis to the public health aspects of sanitation.

There are also many higher institutions whose curricula include a larger or smaller number of components related to sanitary engineering, but in general they do not offer any scientific courses in public health. Such institutions include the National School of Bridges and Highways, the National School for the Preservation of Rural Areas, Water and Forests, ENITRTS, ENTPE (some optional courses), schools of mining, schools of agriculture and a number of national higher schools of chemistry.

Some universities award the degree of Master of Science and Technology in the fields of water supply or environmental protection, e.g. the Universities of Pau, Poitiers, Montpellier and Chambéry. These high-quality courses do not, however, have a scientific public health orientation.

Many universities have recently set up programmes in environmental science oriented to ecology and waste disposal, but in general they do not lead to a diploma in engineering and are not oriented to public health.

WHO reference centres in the field of public health include:

(*a*) ORSTOM — the Department of Hydrology at the Overseas Scientific and Technical Research Office, Paris; this institution is devoted exclusively to the problems of foreign countries;

(*b*) CERCHAR — the Study and Research Centre of the French Coal Board, whose activities are oriented towards industrial pollution;

(*c*) the Institute of Hydrological Research, Nancy;

(*d*) CEMAGREF — the National Centre for Agricultural Engineering, Rural Areas, Water and Forests, Lyon, which is in charge of the development of agricultural engineering;

(*e*) IRCHA — the National Institute of Applied Chemistry Research, south of Paris, which is especially oriented towards chemical engineering and pollution control.

Addresses

Ministry of Social Affairs and National Solidarity
Secretariat of State for Health and Directorate-General of Health
(Ministère des Affaires sociales et de la Solidarité nationale
Secrétariat d'Etat chargé de la Santé, et Direction générale de la Santé)
1 place Fontenoy
75700 Paris

Tel. 567 55 44

Secretariat of State for the Environment
(Secrétariat d'Etat chargé de l'Environnement)
14 boulevard du Général Leclerc
92521 Neuilly sur Seine Cedex

Tel. 758 12 12

National School of Public Health
(Ecole nationale de la Santé publique (ENSP))
Avenue du Professor Léon Bernard
35043 Rennes Cedex

Tel. (99) 59 29 36

National School of Civil Engineering
(Ecole nationale des Travaux publics de l'Etat (ENTPE))
Rue Maurice Audin
69120 Vaux-en-Velin

Tel. 820 00 84

National School of Rural Engineering and Sanitary Technology
(Ecole nationale des Ingénieurs des Travaux ruraux et des Techniques sanitaires (ENITRTS))
1 Quai Koch
B.P. 1039
67070 Strasbourg Cedex

Tel. (88) 35 67 72

National School of Bridges and Highways
(Ecole nationale des Ponts et Chaussées)
28 rue des Saints-Pères
75007 Paris

Tel. (1) 260 34 13

National School for the Preservation of Rural Areas, Water and Forests
(Ecole nationale du Génie rural, des Eaux et des Forêts)
19 avenue du Maine
75015 Paris

Centre de Nancy
14 rue Girardet
54042 Nancy Cedex

Tel. (8) 335 10 20

University of Savoy (Chambéry)
(Université de Savoie (Chambéry))
Domaine universitaire de Jacob-Belle Combette
B.P. 143
73011 Chambéry Cedex

Tel. (79) 69 27 18

University of Montpellier II (Languedoc University of Science and Technology)
(Université de Montpellier II (Université des Science et Techniques du Languedoc))
Place Eugène Bataillon
34060 Montpellier Cedex

Tel. (67) 63 91 44

University of Pau and the Pays de l'Adour
(Université de Pau et des Pays de l'Adour)
68 rue Montpensier
B.P. 576 Pau-Université
64010 Pau Cedex

Tel. (59) 32 56 47

University of Poitiers
(Université de Poitiers)
15 rue de Blossac
86034 Poitiers Cedex

Tel. (49) 88 26 32

Overseas Scientific and Technical Research Office
(Office de la Recherche scientifique et technique d'Outremer (ORSTOM))
24 rue Bayard
75008 Paris

Tel. 723 38 29

Study and Research Centre of the French Coal Board
(Centre d'Etudes et Recherches des Charbonnages de France (CERCHAR))
B.P. 2
60550 Verneuil-en-Halatte

Tel. (4) 455 35 00

Institute of Hydrological Research
(Institut de Recherches hydrologiques)
10 rue Ernest Bichat
54000 Nancy

Tel. (8) 396 65 10

National Centre for Agricultural Engineering, Rural Areas, Water and Forests
(Centre national du Machinisme agricole, du Génie rural, des Eaux et des Forêts (CEMAGREF))
8 Quai Chauveau
69009 Lyon

Tel. (78) 83 49 48

National Institute of Applied Chemistry Research
(Institut national de Recherche chimique appliquée (IRCHA))
B.P. 1
91710 Vert-le-Petit

Tel. (6) 493 24 75

German Democratic Republic

The German Democratic Republic is bordered by the Federal Republic of Germany to the west and south, Czechoslovakia to the south-west and Poland to the east; to the north is the Baltic Sea.

Considerable importance is attached to the proper planning of industry and utilities in order to minimize pollution. Responsibility for reducing wastes is assigned to enterprises themselves, and the costs of community treatment of wastes may be recovered from the polluter.

There is no exact equivalent to the term sanitary engineer in the German Democratic Republic, although the term *Gesundheitsingenieur* (health engineer) comes closest. As in many other countries, it has become customary

to use the more comprehensive term environmental engineer (*Umweltsingenieur*). Engineers with training in sanitary engineering are employed in government offices, municipalities, industry and construction.

The principal institute for engineering training is the Technical University of Dresden, where there are opportunities for graduate studies with specialization in the health aspects of environmental pollution. The Institutes of Technology at Merseburg, Leipzig and Ilmenau provide basic training in civil engineering.

Addresses

Technical University of Dresden
(Technische Universität Dresden)
Faculty of Civil Engineering, Hydraulics and Forestry
Mommsenstraße 13
8027 Dresden

Tel. 463 43 12

Merseburg Institute of Technology
(Technische Hochschule "Carl Schorlemmer", Leuna-Merseburg)
Geusaer Straße
42 Merseburg

Leipzig Institute of Technology
(Technische Hochschule Leipzig)
Karl-Liebknecht Straße 132
7030 Leipzig

Ilmenau Institute of Technology
(Technische Hochschule Ilmenau)
Postfach 327
6300 Ilmenau

Federal Republic of Germany

The Federal Republic of Germany is bounded in the north by Denmark and the Baltic Sea, in the east by the German Democratic Republic and Czechoslovakia, in the south by Austria and Switzerland, and in the west by France, Luxembourg, Belgium, the Netherlands and the North Sea.

The country is a social and democratic federal state with a two-chamber Federal Parliament: the Upper House (*Bundesrat*), which is composed of representatives of the eleven states or *Länder*, and the Lower House (*Bundestag*), which is composed of elected representatives. Each *Land* has its own legislative assembly, which can pass laws except in matters that are

exclusively the right of the Federal Parliament. Local responsibility for the execution of federal and state laws rests with the city and county authorities (*Kreise*). The *Länder* have limited authority to conclude treaties with neighbouring countries regarding *inter alia* the environment and nature protection.

The Federal Government is assisted by a number of councils and commissions, which make recommendations that frequently become the basis for federal or state legislation. Thus, the Council of Experts on Environmental Questions advises the Ministry of the Interior, and the Ministry of Food, Agriculture and Forestry is assisted by the Advisory Council on Nature Conservation and Landscape. The private Association of German Engineers (VDI) has prepared extensive sets of standards for measuring environmental parameters.

There is no official definition of the term *Gesundheitsingenieur* in German. When that term is used, it signifies an engineer whose professional tasks are primarily in the fields of water supply, wastewater treatment and disposal (municipal and industrial), water pollution control, and solid wastes collection and disposal. Most engineers in this category are engaged in water resources management or in the planning, design and operation of systems, plants, structures and equipment. In addition to this type of engineer, another type, the environmental engineer, is being trained for professional positions. The newly established branch of environmental engineering is intended to cover a much wider field of managerial and technological activities aimed at protecting and improving the human environment and health.

Engineers with special training in sanitary engineering hold most of the responsible positions in the fields of water resources management, water quality control, water supply, wastewater treatment and disposal, solid wastes treatment and disposal, and also in other fields of environmental protection. Their relative distribution in the different professional areas is approximately as follows:

state and federal service (management, planning, supervision, legal and administrative activities)	25%
municipal service: waterworks, wastewater departments, solid wastes department (management, supervision, planning, construction, plant operation, administration)	35%
industry (protection of environment and health within the factory, production of equipment for sanitary engineering and environmental protection)	10%
consultation (primarily the planning and design of plants)	20%
teaching and research	10%

Study courses in the various fields of engineering are offered by the technological universities and by another more practically oriented type of teaching institute, the polytechnic (*Fachhochschule*).

Admission to the universities, including the technical universities, is open to candidates who have graduated from the secondary school (*Gymnasium*) after 13 years of education. Admission to a polytechnic is possible after 12 school years have been completed. At least 6 months of practical work have to be carried out by students before they start at a university or polytechnic. The duration of the engineering curriculum is 4 years (i.e. 8 semesters) at the university, while at the polytechnic it is 3 years (i.e. 6 semesters) plus 2 semesters of practical training in a factory, laboratory, construction site, etc. Both curricula lead to the degree of engineer (*Diplom-Ingenieur*).

At undergraduate level, courses in environmental protection and sanitation and in technical hygiene are offered by the technical universities and polytechnics in Berlin (West), Bingen, Hamburg, Giessen, Konstanz, Lübeck, Munich and Stuttgart.

There is no special 4-year curriculum in sanitary engineering at the technical universities. Engineers working in the field of sanitary engineering may possess a diploma in civil engineering, mechanical engineering, chemical engineering or process engineering. Most of them are civil engineers with some specialized education in sanitary engineering. Most technical universities offer a curriculum of civil engineering which is subdivided during the last two semesters (i.e. semesters 7 and 8), thus allowing specialization in different fields such as construction engineering, hydraulic engineering and traffic engineering. Such a curriculum is offered by the University of Stuttgart (see Part III).

At present there are no full-time postgraduate training courses in sanitary engineering at the technical universities which can lead to an advanced academic degree comparable with the Master's degree. However, current discussions on this subject in the civil engineering faculties of a few technical universities may lead to the development of postgraduate study courses in sanitary engineering in the near future.

Hitherto, postgraduate work at university institutes of sanitary engineering has consisted mainly in the graduate student's participation in research project work, mostly as a research assistant or as a candidate for the Doctor's degree. Furthermore, engineers in the field of sanitary engineering, regardless of whether they are engaged in research or practical work, have the opportunity to increase their knowledge by attending seminars on different aspects of sanitary engineering which are held regularly by all the leading university institutes and also by professional associations such as the German Gas and Waterworks Association and the Water Pollution Control Association. These seminars last from one day to one week.

Continuing education courses and activities in the field of environmental sanitation have been developed by several universities and polytechnics, including the Technical University of Berlin (West), the Giessen Polytechnic, the University of Stuttgart, and the Institute for Water Economy and Soil Protection, Essen.

About 7 years ago, a full 8-semester curriculum of environmental engineering was developed by the Technical University of Berlin (West), which so far is the only university to have taken that step. Training programmes in the field of environmental protection are also offered by four polytechnics.

In the curriculum of the Technical University of Berlin (West) the traditional fundamentals of civil or sanitary engineering are almost completely replaced by ecological, economic, sociological and public health elements. The curriculum has been developed with the idea of training environmental engineers for employment primarily in the industrial field (development and production of equipment for environmental control and protection, hygiene and health protection in factories, industrial wastes treatment and disposal, recycling), in the state and municipal service (management, planning, supervision, control activities, administration directed towards water and air pollution abatement, public hygiene and health protection), and in research institutes concerned with the area of environmental protection.

The Central Office for Wastes Disposal, at the Federal Office of Environmental Protection in Berlin (West), is a WHO collaborating centre for wastes disposal.

Addresses

Berlin Technical University
(Technische Universität Berlin)
Straße des 17 Juni 135
1000 Berlin (West) 12

Tel. (030) 31 41

Bingen Polytechnic
(Fachhochschule Rheinland-Pfalz Bingen)
Department of Transport
Rochusallee 4
6530 Bingen 1

Giessen Polytechnic
(Fachhochschule Giessen)
Department of Sanitary Engineering
Wiesenstraße 14
6300 Lahn-Giessen 1

Hamburg Polytechnic
(Fachhochschule Hamburg)
Department of Production and Transport
Winterhuder Weg 29
2000 Hamburg 76

University of Konstanz
(Universität Konstanz)
Faculty of Biology
Postfach 5560
7750 Konstanz

Tel. 07531 881

Lübeck Polytechnic
(Fachhochschule Lübeck)
Department of Natural Sciences
Stephensonstraße 3
2400 Lübeck

Munich Technical University
(Technische Universität München)
Faculty of Civil Engineering
Arcisstraße 21
Munich

Tel. 21 051

Munich Polytechnic
(Fachhochschule München)
Department of Engineering
Lothstraße 34
8000 Munich 2

Tel. 21 051

University of Stuttgart
(Universität Stuttgart)
Faculty of Hydraulics and Transport
Keplerstraße 7
7000 Stuttgart

Tel. 20731

Federal Office of Environmental Protection
(Umweltbundesamt)
Bismarckplatz 1
1000 Berlin (West) 33

Tel. (30) 890 31

Association of German Engineers
(Verein Deutscher Ingenieure (VDI))
Graf-Recke Straße 84
Postfach 1139
4000 Düsseldorf 1

Tel. (0211) 621 41

German Gas and Waterworks Association
(Deutscher Verein des Gas- und Wasserfaches e.V. (DVGW))
Frankfurter Allee 27
6236 Eschborn

Water Pollution Control Association
(Abwassertechnische Vereinigung e.V. (ATV))
Markt 71
5205 St. Augustin 1

Greece

The mainland of the Hellenic Republic is a mountainous peninsula bordering the Ionian, Libyan and Aegean Seas, with numerous islands to the south, east and west. The country has frontiers with Albania, Bulgaria, Turkey and Yugoslavia.

Government services are centralized in the capital, Athens. Academic institutions are state-controlled and are mainly the responsibility of the Ministry of Education.

Sanitary engineers are employed in the central administration and in engineering firms. The Ministry of Health and Welfare has a Division of Environmental Health Protection.

Undergraduate training in civil engineering is given at the National Technical University of Athens, the Aristotelian University of Salonica, the University of Patras and the Democritean University of Thrace. While some aspects of public health engineering are included, more emphasis is given to environmental engineering, and there is as yet no specialized training course for sanitary or public health engineers. Nevertheless, provision has been made for a postgraduate course for sanitary engineers at the Athens School of Hygiene, in the Ministry of Health and Welfare. Short courses (1–2 weeks) in environmental sanitation and sanitary engineering are currently available (85 hours per academic year) to physicians and others attending post-graduate courses that lead to a diploma in public health.

Addresses

National Technical University of Athens
Faculty of Civil Engineering
42, 28 Octovriou Street
Athens

Tel. 36 16 922

Aristotelian University of Salonica
Faculty of Technology
Salonica

Tel. 99 15 28

University of Patras
Patras

Tel. 99 18 22

Democritean University of Thrace
Xanthi

Tel. 26 144

School of Public Health
Ministry of Health and Welfare
196 Alexandras Avenue
Athens

Tel. 64 64 472

Hungary

The Hungarian People's Republic is situated in eastern Europe. It has borders with the USSR, Romania, Yugoslavia, Austria and Czechoslovakia. Government is centralized in the capital, Budapest.

The post of sanitary engineer is not recognized in the civil service. However, there are many engineers whose training includes significant studies related to public health. They are employed in the Ministry of Health and the Ministry of Public Works, the National Water Board, the National Institute of Hygiene (OKI), and in the municipal and regional sanitary and epidemiological stations (*Köjal* or *sanepid*), located throughout the country.

The *Köjal* are responsible for all aspects of public health, both medical and engineering, including workers' health and environmental pollution.

Basic engineering, including civil engineering, is taught at the Technical University of Budapest (see Part III), the Technical University of Heavy Industry, Miskolc, and at the Veszprém University of Chemical Engineering. Specialized advanced courses in the public health aspects of engineering are usually taken on a part-time basis, while the student is employed as, for example, a junior engineer. Advanced training is offered at the Technical University of Budapest, at OKI, and at the Research Centre for Water Resources Development (VITUKI). The latter also offers special programmes in water management, including water supply and treatment. Some of these courses are given in English, particularly those organized in collaboration with international bodies such as WHO, WMO, FAO and UNESCO. VITUKI maintains a WHO collaborating centre for water resources protection. Other courses are given in Hungarian, but students are required to know Russian and either German or English.

In addition, a four-semester programme of postgraduate specialization in environmental protection is available at the Technical University of Heavy Industry, Miskolc.

Addresses

Technical University of Budapest
(Budapesti Müszaki Egyetem)
Faculty of Civil Engineering
3 Müegyetem-Rkp
1521 Budapest

Tel. 66 50 11

Technical University of Heavy Industry
(Nehézipari Müszaki Egyetem)
Faculty of Mechanical Engineering
3515 Miskolc-Egyetemvaros

Tel. 13 691

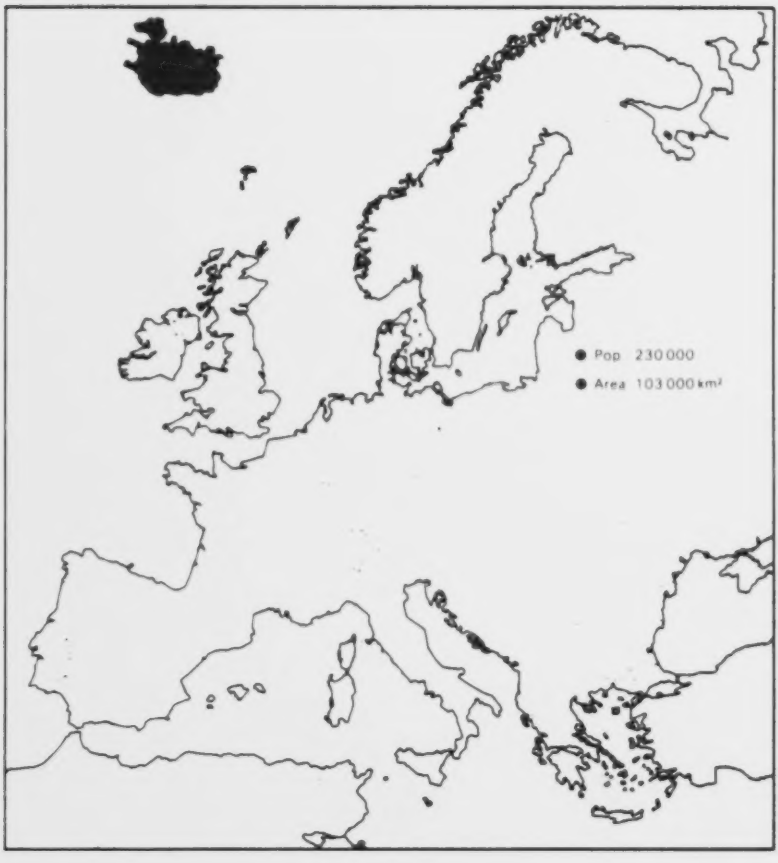
Veszprém University of Chemical Engineering
(Veszprémi Vegyipari Egyetem)
Schönherz Z. u. 10
8201 Veszprém

Tel. 12 550

Research Centre for Water Resources Development
(Vizgazdalkodasi Tudomanyos Kutatoközpont (VITUKI))
P.O. Box 27
1453 Budapest 92

Tel. 33 81 60

National Institute of Hygiene
(Orszagos Közegészségügyi Intezet (OKI))
Gyali u. 2–6
P.O. Box 64
1966 Budapest IX
Tel. 14 22 50



Iceland

The Republic of Iceland lies in the North Atlantic just south of the Arctic Circle. It is a member of the Nordic Council and academic qualifications obtained in any of the other Nordic countries (i.e. Denmark, Finland, Norway and Sweden) are recognized in Iceland. Candidates for academic positions from any of the five countries have equal status, preference being given to local candidates only if their qualifications are otherwise equivalent. In general, instruction is given in Icelandic, but some instruction may be given in Danish. No courses are conducted in English, French or German.

The Faculty of Engineering and Science at the University of Iceland offers courses leading to the degree of civil engineer. Although courses in microbiology, parasitology and virology are offered by the Department of Biology, the civil engineering student is unlikely to be able to fit them into his programme. The Technical College of Iceland offers a programme for civil and structural engineers, with emphasis on water, sewerage and heating systems. Neither institution offers specialized training for sanitary engineers.

The 1981 law on sanitation and health control (No. 50) established the National Centre for Hygiene, Food Control and Environmental Protection. Its responsibilities include the training and instruction of public health officers, in consultation with the appropriate departments of the University of Iceland.

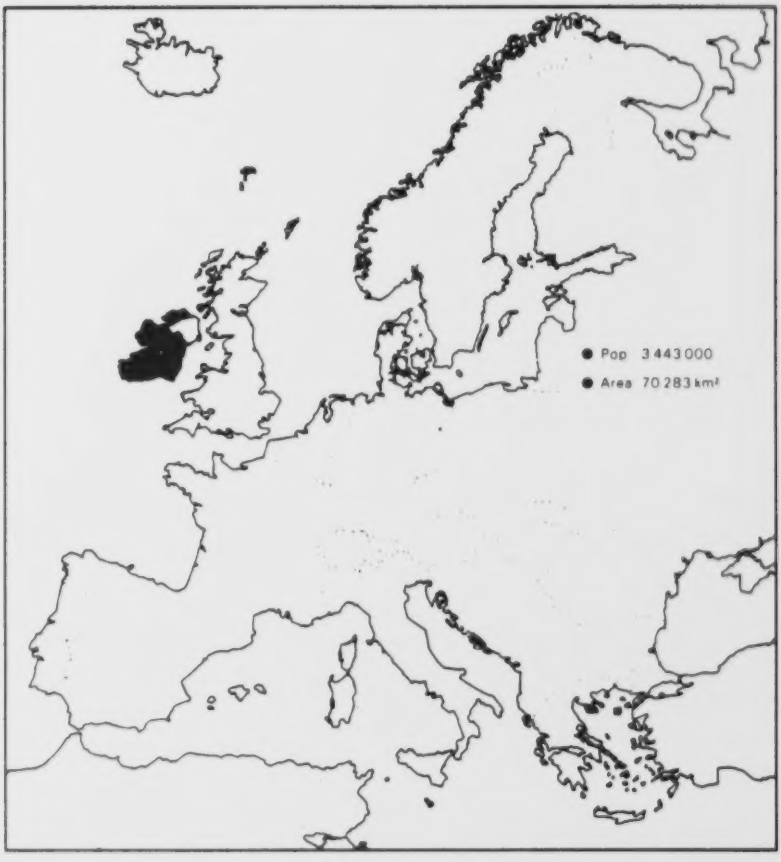
Addresses

University of Iceland, Faculty of Engineering and Science
(Haskoli Islands, Verkfraedi- og Raunvisindadeild)
Hjardarhagi 2–6
Reykjavik

Tel. (91) 250 88

Technical College of Iceland
(Taekniskoli Islands)
Höfdabakka 9
Reykjavik

Tel. (91) 849 33



Ireland

Ireland is situated in the Atlantic Ocean west of Great Britain, from which it is separated by the Irish Sea. Government services are centrally administered from the capital, Dublin.

Civil engineers, whose education includes courses in public health engineering, are employed at various levels in central and local government offices and also in consultant engineers' offices.

Courses in public health engineering form part of the undergraduate civil engineering programmes at the constituent university colleges of the National University of Ireland, located in Cork, Dublin and Galway.

Instruction is given in the English language. Additional (optional) undergraduate courses in engineering microbiology are offered at University College, Galway. There are no regular postgraduate engineering courses in the public health field, but short courses are occasionally organized by the University. Many Irish public health engineers obtain their postgraduate training and experience abroad.

Addresses

National University of Ireland
49 Merrion Square
Dublin

Tel. 767246–7

University College
Faculty of Engineering and Architecture
Belfield
Dublin 4

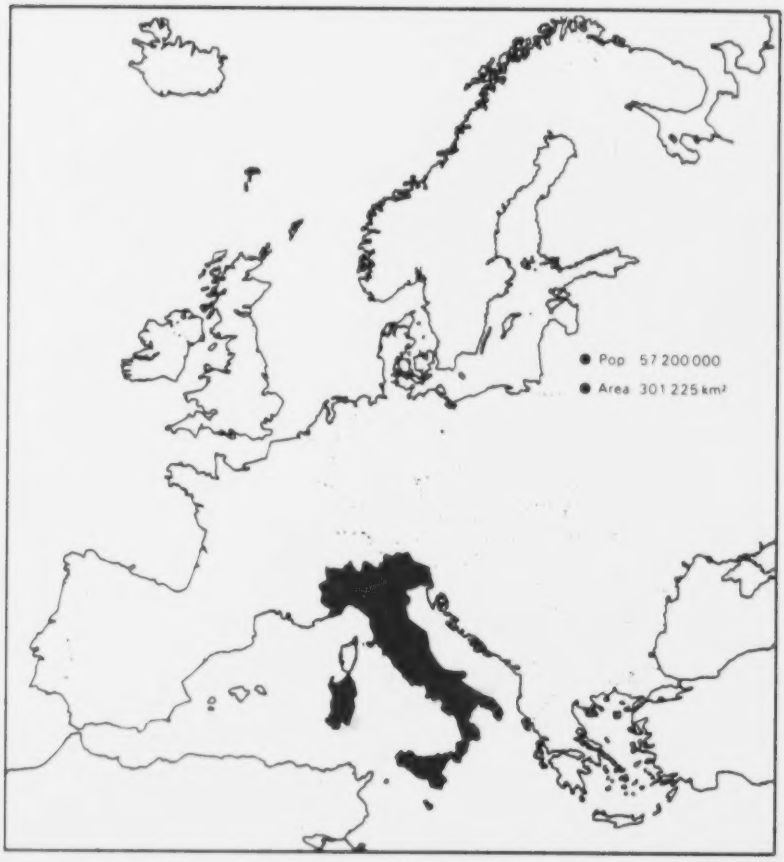
Tel. 693244

University College
Faculty of Engineering
Cork

Tel. 021–26871

University College
School of Engineering
Galway

Tel. 091–24411, ext. 170



Italy

The Italian Republic is a peninsula extending from southern Europe into the Mediterranean Sea, together with a number of adjacent islands, the largest being Sicily to the south and Sardinia to the west. To the north it has frontiers with France, Switzerland, Austria and Yugoslavia. Regional governments operate as decentralized units of the central Government in Rome. Five regions have special status. The universities are all under state control.

Engineers with training in sanitary engineering are employed in environmental control departments of municipal, regional and national government, and in engineering firms.

Undergraduate courses in the public health aspects of engineering are offered by most of the university faculties of engineering; sometimes these courses are compulsory, as for a degree in hydraulic engineering. However, an option in sanitary engineering will not be mentioned on the diploma, which may include only one subsection, e.g., civil engineer, subsection hydraulics.

In undergraduate training the emphasis is more on environmental than on human health problems. Training in many aspects of water and air pollution control is also provided by chemical engineering faculties, while other fields of environmental protection are included in courses offered by natural science faculties.

The university engineering programmes require five years of study: the first two are devoted to basic subjects, the last three to applied studies. The first degree, which requires completion of a thesis, is considered to be equivalent to the degree of Master of Science.

The only institution offering a complete graduate programme in sanitary engineering is the Faculty of Engineering of the University of Naples (see Part III). There is currently a one-year course leading to a diploma of specialist in sanitary engineering for students who enter with a degree in engineering. Strong emphasis is placed on water problems, but optional courses in air pollution and solid waste disposal and treatment are also available. Changes in the curriculum to include more environmental subjects and impact assessments and to expand the programme to cover two years are foreseen. Students from other disciplines are admitted to the programme but receive only a certificate of attendance. Instruction is in Italian, but assistance is available for students speaking Spanish, French or English. The Faculty of Medicine at the University of Naples offers a course in sanitary engineering as part of the curriculum for medical specialists in public health and hygiene.

A research doctorate programme in sanitary engineering has recently been instituted by a consortium comprising the engineering faculties of Milan, Naples, Pavia and Rome, the Chair of Chemical and Industrial Microbiology, Naples, and certain extra-universitary institutes, including the Higher Institute of Health, the Water Research Institute of the National Research Council and the Zoological Station of Naples, together with some industrial groups.

The doctorate programme will be centred on the Sanitary Engineering Institute, Milan, and the courses will last three years. Training and research will be carried out at the different centres after an initial instruction phase in Milan. Students will be admitted to the doctorate course by competitive examination; foreign students will be able to participate on a special basis. Those completing the course will obtain the diploma of research doctor in sanitary engineering.

A European University Institute for Water is being formed in Trieste on the initiative of the Division of Higher Education and Research of the Council of Europe.

Short courses of continuing education are offered at a number of institutions. The Milan Polytechnic offers a number of postgraduate courses on

an *ad hoc* basis, many of which deal with engineering aspects of public and environmental health. Each course lasts one or two weeks and participants receive a certificate of attendance. Some courses are given in German and English.

The University of Rome offers short courses sponsored by the Italian National Association of Engineers and Architects (ANIAI). Courses offered have covered such subjects as: noise, hospital architecture, solid waste and industrial wastewater treatment. A certificate of attendance is issued and students with various technical diplomas are accepted.

The National Association of Sanitary Engineering (ANDIS), together with faculties of engineering at the Universities of Milan, Pavia and Cosenza, organizes a number of training courses in special subjects.

Addresses

University of Naples, Institute of Sanitary Engineering
(Università di Napoli, Istituto d'Ingegneria Sanitaria)
Via Claudio, 21
80125 Naples

Tel. 62 03 44

Milan Polytechnic, Institute of Sanitary Engineering
(Politecnico di Milano, Istituto di Ingegneria Sanitaria)
Via Fratelli Gorlini
20151 Milan

Tel. (02) 4520354–4520543

University of Rome
(Università degli Studi)
Città Universitaria
00100 Rome

Secretary of Permanent Instruction
(Continuing Education)
Piazza Sallustio 24
00187 Rome

European University Institute for Water
Trieste

(c/o Dr J.P. Masse
Head, Division of Higher Education and Research
Council of Europe
67006 Strasbourg Cedex
France)

National Research Council of Italy
(Consiglio Nazionale delle Ricerche (CNR))
Piazzale Aldo Moro 7
00185 Rome

Tel. 49931

Institute of Water Research
(Istituto de Ricerca sulle Acque)
Via Reno 1
00198 Rome

National Association of Sanitary Engineering
(Associazione Nazionale d'Ingegneria Sanitaria (ANDIS))
Piazza Sallustio 24
00187 Rome

Tel. 48 64 15

Luxembourg

The Grand Duchy of Luxembourg lies to the south-east of Belgium between France and the Federal Republic of Germany.

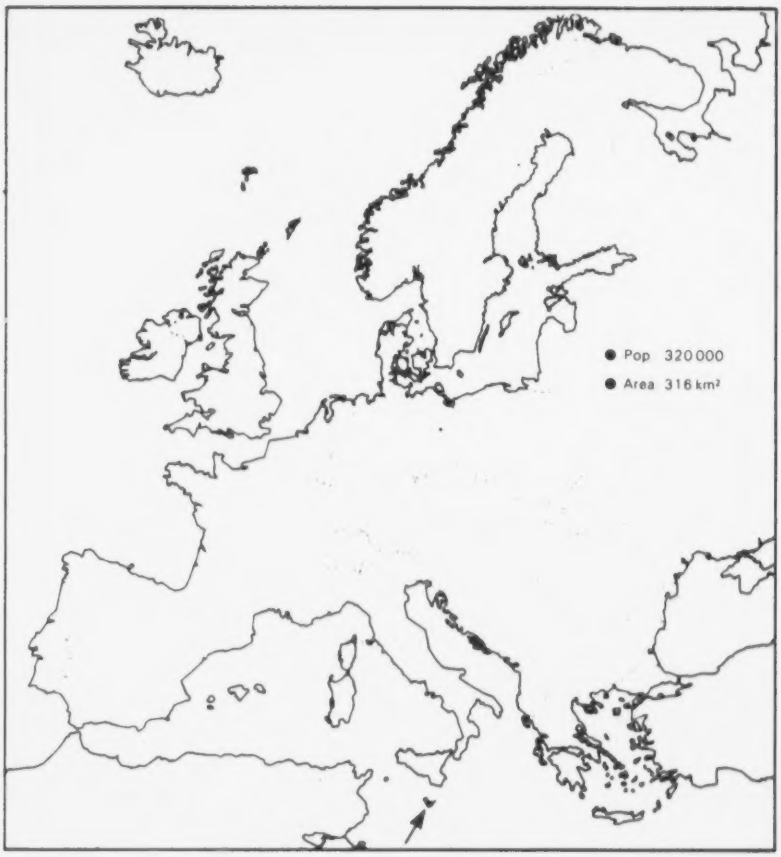
General engineering is taught (in the French language) at the Higher Institute of Technology.

Students wishing to specialize in sanitary engineering have to attend universities or institutes in other countries.

Addresses

Higher Institute of Technology
(Institut supérieur de Technologie)
School of Technical Engineering
Rue Richard Coudenhove-Kalergie
1359 Luxembourg-Kirchberg

Tel. 436661



Malta

The Republic of Malta consists of a group of islands in the Mediterranean Sea, the largest being Malta, Gozo and Comino. It lies between Sicily and the African coast.

The position of sanitary engineer does not exist as such within the administrative framework. Under the Ministry of Health a new board has been established to advise the Minister on environmental matters related to air pollution. Basic sanitation and environmental pollution control constitute special services of the Department of Health (under the Ministry of Health).

Engineers collaborate at various levels in developing the relevant programmes and activities. There is no formal training in the field of sanitary engineering. The traditional areas of environmental health are covered to a certain extent by the Faculty of Engineering and Architecture of the University (undergraduate level) and the School of Public Health (postgraduate level).

Addresses

University of Malta
Msida

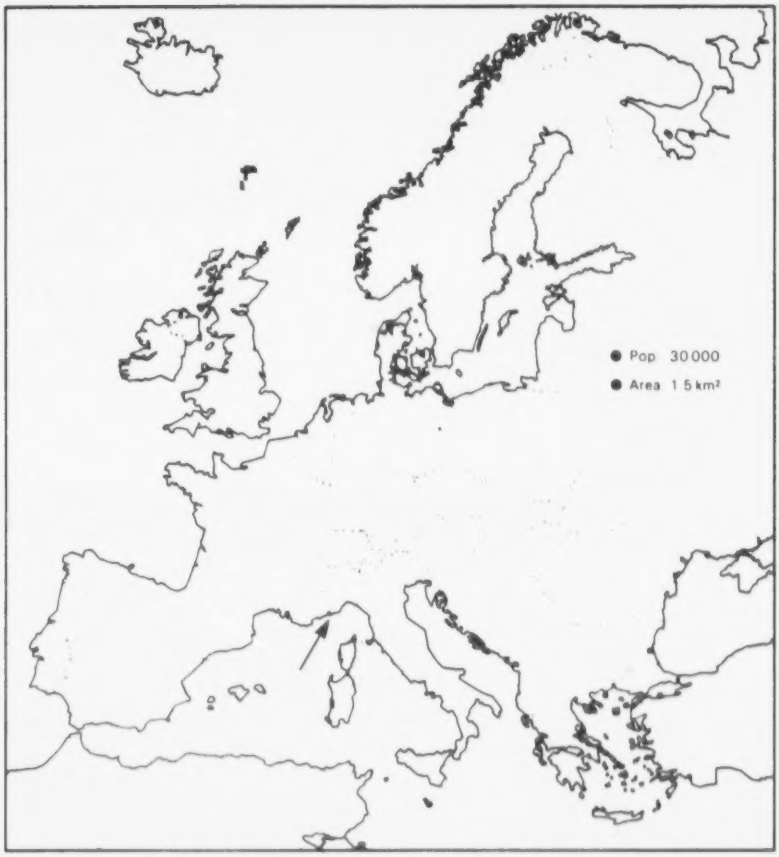
Tel. 36451/9

Faculty of Engineering and Architecture

Faculty of Medicine and Surgery

School of Public Health

Chamber of Architects and Civil Engineers
1 Wilga Street
Paceville
St. Julian's



Monaco

The Principality of Monaco, an independent and sovereign state, is located on the south-eastern coast of France, where it constitutes an enclave, close to the Italian border.

The Principality has no institutions offering university education. Those wishing to undertake studies in sanitary engineering generally go to universities or institutes of higher education in France. There are no specific posts for sanitary engineers within the administration.

Morocco

The Kingdom of Morocco is located in the north-west of Africa between Algeria and Mauritania; it has coastlines on both the Mediterranean Sea and the Atlantic Ocean. Government services are centralized in the capital, Rabat.

The training of sanitary engineers was initiated in the 1960s at the Mohammedia Engineering School (EMI), Rabat, with the assistance of the WHO Regional Office for Europe. The Department of Sanitary Engineering was originally established as an international sanitary engineering centre to meet the needs of Moroccan and other French-speaking developing countries.

Since September 1981 the programme of the renamed Department of Environmental Engineering has been conducted under the direction of Moroccan teachers. Environmental health courses are given by teachers of the EMI and specialists attached to the Ministry of Public Health. Instruction is given in French and leads after five years to the degree of environmental engineer (see Part III).

Preliminary training may be given at other technical institutes, but the last two years of the programme must be taken at the EMI. During these two years students of civil engineering specialize in one of three divisions: buildings, bridges and highways, hydraulics or environmental engineering.

While emphasis is on drinking-water supply and sewage disposal, there are courses in solid wastes, urban problems and the quality of the environment, including air pollution and workers' health.

The fifth year of the course includes an extended independent project related to the students' special needs.

Addresses

Department of Environmental Engineering
Mohammedia School of Engineering
Mohammed V University
B.P. 554
3 rue Michlifen
Rabat — Agdal

Netherlands

The Kingdom of the Netherlands is bounded by the Federal Republic of Germany to the east, by Belgium to the south and by the North Sea to the west and north. The ministries are located not in the capital, Amsterdam, but in and around The Hague. Many government services have, however, been decentralized and are located in various parts of the country.

Students who wish to qualify for a career in sanitary engineering can take a degree either at the Delft University of Technology or at the University of Agriculture, Wageningen. The degree of sanitary engineer as such

does not exist. In order to obtain the necessary qualifications one has either to take the degree of civil engineer at Delft, with a major option in sanitary engineering, or to take the degree of agricultural engineer at Wageningen, with a major option in environmental hygiene.

A reform was made in the organization of universities in the Netherlands with effect from September 1982. The duration of the normal university curriculum is now four years.

The Civil Engineering Department of the University of Technology, Delft, has a sanitary engineering section. All future civil engineers have to take a general course in water supply, wastewater treatment and general sanitation. Those who opt for sanitary engineering as their undergraduate specialization have, in addition to regular civil engineering subjects, to take a number of subjects relevant to sanitary engineering, such as chemistry, microbiology, health sciences. The nucleus of the sanitary engineering specialization programme is a series of lectures and practical exercises in drinking-water supply and the treatment of wastewater and solid wastes. Each student has to make a major design study in his field of specialization before graduating. The Department has a well equipped laboratory where the unit operations of sanitary engineering can be conducted.

The University of Agriculture at Wageningen has, in its laboratories for water purification and for health sciences, excellent facilities for teaching a number of subjects relevant to sanitary engineering. Agricultural engineers who specialize here in environmental hygiene can work later on a wide range of problems related to water quality control, monitoring and environmental parameters, rural sanitation, and domestic and agricultural wastes. During the first two years of their four-year curriculum, students take a programme of biology, physics and chemistry, together with agronomy and introductory engineering subjects. The last two years are devoted to specialization. Besides the lectures there is an ample programme of laboratory and field-work.

Although the legislation on university education does not provide for a separate degree in sanitary engineering, the functions of the sanitary engineer in government, industry and scientific institutes are adequately taken care of by civil engineers and agricultural engineers who have specialized in sanitary engineering.

A foundation offering short courses in sanitary engineering was established by the Netherlands technological universities, together with the Royal Institute of Engineers, in 1960. Courses, each lasting from three to eight days, are offered in a wide range of sanitary engineering and public health subjects. Participants are engineers and technicians working in practice; many of them come from the Flemish-speaking part of Belgium.

At the 15 technical colleges that offer civil engineering, water supply and sanitation are included as course subjects. All these colleges have laboratory facilities. The engineers graduating from these colleges take an important part in the design, construction and operation of sanitary engineering works.

The activities of the International Institute for Hydraulic and Environmental Engineering (IHE), Delft, are directed towards the needs of developing countries. The Institute offers postgraduate courses in water-related subjects. The sanitary engineering programme is designed for engineers with at least three years of practical experience. The courses last 10½ months and are conducted in English (see Part III).

There are two programmes in sanitary engineering: programme I is directed at the needs of industrial areas, programme II at the needs of rural areas. Most participants have previous education as civil engineers, although agricultural, chemical and mechanical engineers have also been admitted. In the first months work is done in the laboratories on general and environmental chemistry and microbiology. Later in the year students work in the unit operations laboratories and undertake field measurements in treatment plants and in open waters. The programmes of both courses cover chemistry, microbiology, hydraulics, water distribution and sewage collection, unit treatment processes and operations, water resources management and systems analysis. The participants of programme I take, in addition, industrial wastes and atmospheric pollution, whereas the participants of programme II pay special attention to public health administration, epidemiology and rural sanitation. The programmes are design-oriented, and much time is therefore devoted to preparing designs of treatment plants or pollution management schemes.

The IHE also runs a programme in environmental science and technology intended for graduates in chemistry or biology who have an adequate background in mathematics and at least three years of relevant practical experience. The programme starts with instruction in chemistry, biology, microbiology and statistics and goes on to consider a broad spectrum of environmental problems and their management. Participants spend much time on laboratory work and field measurements. Towards the end of the programme each participant prepares a thesis on an environmental problem encountered in his country. Wherever possible, joint activities are undertaken by participants in the sanitary engineering and/or the environmental courses, so that they become accustomed to working together.

In addition to the regular programmes described above, the IHE organizes tailor-made courses on demand. Some of these programmes are conducted at the Institute in Delft, while other course activities may be organized abroad. An example of such a programme is that on water pollution monitoring and management, organized in autumn 1983 for the third time on behalf of the WHO Regional Office for South-East Asia.

The WHO International Reference Centre for Community Water Supply and Sanitation (IRC) is a worldwide centre for activities connected with the United Nations Drinking Water Supply and Sanitation Decade. The Institute for Waste Research (IVA) is a WHO collaborating centre for solid waste research. These WHO collaborating centres develop valuable material for training and instruction, although they do not offer courses themselves.

Addresses

University of Agriculture
(Landbouwhogeschool)
Salverdaplein 10, 6701 DB
P.O. Box 9101
6700 HB Wageningen

Tel. (08370) 89111

Delft University of Technology
(Technische Hogeschool Delft)
Julianalaan 134, 2628 BL
P.O. Box 5
2600 AA Delft

Tel. 015-78 91 11

Eindhoven University of Technology
(Technische Hogeschool Eindhoven)
Den Dolech 2, 5612 AZ
P.O. Box 513
5600 MB Eindhoven

Tel. 040-47 91 11

Twente University of Technology
(Technische Hogeschool Twente)
Drienderlolaan 5, 7522 NB
P.O. Box 217
7500 AE Enschede

Tel. 053-89 91 11

International Reference Centre for Community Water Supply
and Sanitation (IRC)
J.C. van Markenlaan 5, 2285 VL
P.O. Box 5500
2280 HM Rijswijk

Tel. 070-94 93 22

International Institute for Hydraulic and Environmental
Engineering (IHE)
(Internationaal Instituut voor Waterbouwkunde en Milieubeheer)
Oude Delft 95, 2611 BD
2601 DA Delft

Tel. 010-67 35 40

Netherlands Waterworks Testing and Research Institute
(Keurungsinstituut voor Waterleidingartikelen KIWA n.v.)
Sir Winston Churchill-laan 273, 2288 EA
P.O. Box 70
2280 AB Rijswijk

Tel. 070-90 27 20

Institute for Waste Research
(Instituut voor Afvalstoffenonderzoek (IVA))
Natriumweg 7, 3812 PV
P.O. Box 184
3800 AD Amersfoort

Tel. 033-12904

Norway

The Kingdom of Norway lies in the western part of the Scandinavian peninsula with Sweden to the east; inside the Arctic Circle it borders on Finland and the USSR. The principal services of the Government are centred in the capital, Oslo.

Norway is a member of the Nordic Council and academic qualifications obtained in any of the other Nordic countries (i.e., Denmark, Finland, Iceland and Sweden) are recognized in Norway. Candidates for academic positions from any of the five countries have equal status, preference being given to local candidates only if their qualifications are otherwise equivalent.

The Norwegian Institute of Technology, a constituent part of the University of Trondheim, 400 km north of Oslo, is the only Norwegian institution that provides training in sanitary engineering. The Institute offers standard courses in sanitary engineering as part of the undergraduate programme for civil engineers within the two fields of sanitary engineering and water chemistry. It also offers postgraduate training, with optional specialization in sanitary and public health engineering in the following fields: water supply and sewerage planning; water and wastewater treatment processes; and solid waste handling.

Graduates of both courses are employed by the Government, local authorities and engineering firms, as well as by research institutes such as the Scientific and Industrial Research Foundation at the University of Trondheim, the Norwegian Institute for Water Research and the National Institute of Public Health.

Approximately 1000 candidates with skills in sanitary engineering and public health engineering have graduated within the last decade, the individual study time being some 4–5 years. Undergraduate instruction is given in Norwegian.

At the postgraduate level, the Norwegian Institute of Technology also offers special training programmes in English for sanitary engineers from developing countries.

Addresses

University of Trondheim
(Universitetet in Trondheim)
Trondheim

Norwegian Institute of Technology
(Norges Tekniske Høgskole)
Department of Hydraulic Construction
7034 Trondheim-NTH

Tel. (47–75) 94–000

Scientific and Industrial Research Foundation at
the University of Trondheim
(Stiftelsen for industriell og teknisk forskning ved Norges
tekniske høgskole (SINTEF))
7034 Trondheim-NTH

Norwegian Institute for Water Research
Norsk Institutt for Vannforskning
P.O. Box 333
Blindern
Oslo 3

National Institute of Public Health
Water Department
Oslo 1

Poland

The Polish People's Republic extends from the Baltic Sea in the north to Czechoslovakia in the south, and from the USSR in the east to the German Democratic Republic in the west. Government is centralized in the capital, Warsaw.

The profession of sanitary engineer has long been recognized in Poland. Many engineers with specialized training in public health and environmental engineering are employed in national, provincial and municipal offices, and in sanitary and epidemiological stations throughout the country.

There are five major technical universities in Poland which teach sanitary and environmental engineering. A typical basic course takes three

years, and is followed by 18 months' specialization in one of the following fields: air pollution control; hydrology and water management; heating, ventilation and plumbing; and water and sewage treatment. There are also eight other technical institutions offering training in civil or environmental engineering.

Postgraduate studies in special aspects of sanitary engineering are performed while the student is employed as a junior engineer. The normal pattern is a one-year course consisting of attendance at courses for one week in each month. Advanced courses are offered in: air pollution control; water management; water and sewage treatment; water supply and sewage systems; water and wastewater management in industry; and solid waste disposal.

At the present time, practically all instruction is given in Polish. There are plans to organize an international postgraduate programme in environmental engineering at the Warsaw University of Science and Technology. While emphasis will be placed on protection of the environment, public health aspects will also be included. Instruction in the Russian and French languages for the benefit of students from other countries is envisaged.

The National Institute of Hygiene and the Institute of Meteorology and Water Management also offer advanced training in public health engineering.

Addresses

Warsaw University of Science and Technology
(Politechnika Warszawska)
Faculty of Sanitary and Hydraulic Engineering
1 Plac Jednosci Robotnicze
00661 Warsaw

Tel. 21 00 70

Cracow Technical University
(Politechnika Krakowska)
Faculty of Sanitary and Hydraulic Engineering
24 Warszawska
31155 Cracow

Tel. 30 03 00

Silesia Technical University
(Politechnika Slaska im. W. Pstrowskiego)
Faculty of Sanitary Engineering
7 ul. Pstrowskiego
Gliwice

Tel. 31 23 49

Wroclaw Technical University
(Politechnika Wroclawska)
Faculty of Sanitary Engineering
27 Wybrzeze Wyspianskiego
50370 Wroclaw

Tel. 22 77 36

National Institute of Hygiene
(Panstwowy Zaklad Higieny)
24 ul. Chocimska
Warsaw

Institute of Meteorology and Water Management
61 Podlesna
Warsaw

Portugal

The Portuguese Republic is situated on the Atlantic side of the Iberian peninsula and has borders with Spain in the north and east.

The title of sanitary engineer is not yet officially recognized. Nevertheless, within the Directorate-General of Health the position of Director of Sanitary Engineering is held by a specialist in that field. The professional profile of the sanitary engineer is, however, highly respected. In 1982, there were about 200 sanitary engineers with diplomas, about 10% of whom had obtained their qualifications in other countries.

Sanitary engineering is taught at the undergraduate level at the University of Lisbon in the Faculty of Engineering. Sanitary engineering is included in the basic sanitation courses which form part of the five-year programme leading to the degree of civil engineer, with options in hydrology and urban planning. The Technical University of Lisbon also includes material related to traditional sanitary engineering in its civil engineering programme, under the optional subject "Hydrology and urban planning". The course in basic sanitation emphasizes the hydrological cycles, including pollution, natural purification of water, and water treatment. The treatment of wastewater and solid wastes is also considered.

The Faculty of Science and Technology at the University of Coimbra and the Faculty of Engineering at the University of Oporto offer courses containing material relevant to sanitary and environmental engineering. The New University of Lisbon, in its Faculty of Science and Technology, has developed a programme leading to the degree of environmental engineer.

A specialized 15-month postgraduate programme in sanitary engineering for students with engineering degrees from institutes of higher education in Portugal and abroad has been developed at the New University of Lisbon, with assistance from WHO (see Part III). The programme is divided into three sections, covering theory, applications, and visits to engineering installations. A parallel programme on quality of the environment is open to candidates with degrees in related subjects such as biology, chemistry, pharmacology and medicine. Preference is given to candidates with professional experience in sanitary or environmental engineering, and who have prospects of employment in those fields. Candidates are expected to have a knowledge of a foreign language, preferably English or French.

Three postgraduate specialist courses offered by the National School of Public Health, in public health, occupational health and hospital administration, contain material traditionally considered to be relevant to sanitary and environmental problems. The courses, developed by the Department of Environmental Hygiene and Sanitation, are given to teachers specializing in sanitary engineering.

Intensive continuing education courses for municipal engineers are also organized by the National School of Public Health. Each course requires 120 hours of study over a four-week period, and includes theoretical lectures integrated with practical laboratory work, seminars, and visits to engineering installations. Four courses are currently offered: (*a*) introduction to major problems of sanitary engineering; (*b*) hygiene and the environment; (*c*) prevention of water, air and soil pollution; (*d*) improvement of the environment. Short courses of one or two weeks are currently offered in fluoridation of water, water pollution, air pollution, disinfection of water, and in solid wastes and public health.

The National Civil Engineering Laboratory of the Ministry of Housing and Public Works also offers short courses on, for example, the treatment of wastewaters in lagoons, rural water supplies, and the removal of wastewater in rural areas.

Addresses

University of Lisbon
(Universidade de Lisboa)
Faculty of Engineering
Alameda da Universidade
1699 Lisbon

Tel. 76 76 24

New University of Lisbon
(Universidade Nova de Lisboa)
Faculty of Science and Technology
26/rc Praça do Principe Real
1200 Lisbon

Tel. 36 66 69

Technical University of Lisbon
(Universidade Technica de Lisboa)
Department of Civil Engineering
1 Alameda Santo Antonio dos Capuchos
1100 Lisbon

Tel. 54 54 34, 54 75 69, 40 416, 41 227

University of Coimbra
(Universidade de Coimbra)
Faculty of Science and Technology
Paço das Escolas
3000 Coimbra

Tel. 22 812, 26 088

University of Oporto
(Universidade do Porto)
Faculty of Engineering
Rua D. Manuel II
4003 Oporto

Tel. 69 95 19

Department of Health Planning
Ministry of Social Affairs
25 Avenida Alvares Cabral
1200 Lisbon

Tel. 68 91 17/18/19, 68 93 99

National School of Public Health
(Escola Nacional de Saúde Pública)
Av. Padre Cruz
1699 Lisbon

Tel. 79 24 61, 79 57 16

Directorate-General of Basic Sanitation
Ministry of Housing and Public Works
(Direcçao-Geral do Saneamento Basico
Ministério da Habitaçao e Obras Pùblicas)
44 Rua Antero de Quental
1100 Lisbon

Tel. 57 50 69

National Civil Engineering Laboratory
Ministry of Housing and Public Works
(Laboratorio Nacional de Engenharia Civil
Ministério da Habitaçao e Obras Pùblicas)
Av. do Brasil
1700 Lisbon

Tel. 88 21 31, 88 21 30

Romania

The Socialist Republic of Romania lies to the west of the Black Sea and shares borders with Bulgaria, Yugoslavia, Hungary and the USSR. Government services are centralized in the capital, Bucharest.

There is no degree in sanitary engineering as such. Civil engineers, more commonly known as hydrological engineers, are responsible for water supply and sanitation at the municipal level. Health and hygiene aspects are the responsibility of medical hygienists, who receive their training in medical faculties. Chemical engineers are responsible for pollution control especially at industrial enterprises.

Engineering training is given at the polytechnic institutes in Bucharest, Cluj, Iasi and Timisoara, while the medical aspects of public health engineering are taught at the institutes of hygiene and public health in the same cities.

In Bucharest, both graduate and postgraduate education in all aspects of hygiene and public health is offered; at Cluj, in environmental hygiene; at Iasi, in environmental hygiene and pollution; and at Timisoara, in environmental pollution of water, air and soil.

Addresses

"G. Gheorghiu-Dej" Polytechnic Institute
Hydraulics Research Unit
313 Splaiul Independentei
Bucharest

Tel. 37 20 55

National Institute of Chemistry
132 Calea Crivitei
Bucharest

Tel. 50 32 89

Institute of Construction
Faculty of Hydrotechnical Construction
24 Bulevardul Republicii
Bucharest

Cluj-Napoca Polytechnic Institute
Faculty of Construction
Hydraulics Research Institute
Chemical Technology Research Unit
15 Str. Emil Isac
Cluj-Napoca

Tel. 34 565

"Babes-Bolyai" University, Cluj-Napoca
Faculty of Industrial Chemistry
1 M. Kogalniceanu
Cluj-Napoca

"Gheorghe Asachi" Polytechnic Institute
Faculty of Civil Engineering
Faculty of Chemical Technology
22 Calea 23 August
Iasi

Tel. 13 577

"Traian Vuia" Polytechnic Institute, Timisoara
Faculty of Civil Engineering
Faculty of Chemical Engineering
2 Boulevard Decembrie 30
Timisoara

Tel. 34717

Institutes and centres of hygiene and public health

Institute of Hygiene and Public Health
1-3 Str. Dr Leonte
79636 Bucharest

Institute of Hygiene and Public Health
6 Str. Pasteur
3400 Cluj-Napoca

Institute of Hygiene and Public Health
14 Str. Dr V. Babes
6600 Iasi

Centre of Hygiene and Public Health
16 Bd V. Babes
1900 Timisoara

San Marino

The Republic of San Marino is a land-locked state in central Italy some 20 km from the Adriatic Sea.

The position of sanitary engineer does not exist in the administration and the country has no facilities for training engineers.

Public health engineering duties are carried out by engineers, most of whom obtain their education in Italy, since San Marino has close cultural and administrative ties with that country.

Spain

The Spanish State, situated on the Iberian peninsula and adjacent islands, is bounded by France and the Bay of Biscay to the north, by Portugal and the Atlantic Ocean to the west, and by the Mediterranean Sea to the south and east. The central Government in Madrid has delegated considerable powers to some of the provincial governments, and consideration is being given to further decentralization. At present there is no provision for sanitary engineers as such in the administration. However, the ministries responsible for public health, public works, industry and community services, together with the water supply companies, do employ engineers specialized in the traditional fields of environmental health and sanitary engineering.

Undergraduate training in civil and chemical engineering at the University of Santander, and at the polytechnic universities of Barcelona, Madrid and Valencia, includes subject matter related to the public health aspects of engineering. All four institutions are controlled by the Ministry of Universities and Research.

The four schools of engineering in Spain have been undergoing a process of change in their study programmes in order to achieve higher levels of specialization in their students. The five-year study programmes have been extended to six years, the last two years being devoted in part to a field of specialization chosen by the student. Under the new six-year study programme, students may choose from seven fields of specialization, one of them being that of sanitary engineering.

To graduate, students have to obtain a total of 46 credits during their fifth and sixth academic years (a credit is equivalent to one hour of studies weekly throughout the academic year). Of these credits, 30.5 are for studies in what is considered to be the common compulsory programme for all fields. To be admitted to a field of specialization, students have to obtain at least 16 credits in specialty courses during their last two academic years.

A doctoral programme in sanitary engineering is available at the Polytechnic University of Madrid.

Instruction is primarily in Spanish, but is also given in the Catalan language at the Polytechnic University of Barcelona. At the Polytechnic University of Valencia some instruction is given in English, French and German.

Continuing education programmes are sponsored by the Spanish Institute of Engineering.

Addresses

University of Santander
(Universidad de Santander)
Higher Technical School of Road, Canal and Port Engineers
Avenida de los Castros S/N
Santander

Tel. 21 81 61, 21 99 61

Polytechnic University of Barcelona
(Universidad Politecnica de Barcelona)
Higher Technical School of Road, Canal and Port Engineers
31 Jorge Girona Salgado
Barcelona 34

Tel. 249 38 04, 249 38 03, 249 38 02

Polytechnic University of Madrid
(Universidad Politecnica de Madrid)
Higher Technical School of Road, Canal and Port Engineers
14 Cea Bermudez
Madrid 3

Tel. 254 02 27

Polytechnic University of Valencia
(Universidad Politecnica de Valencia)
Higher Technical School of Road, Canal and Port Engineers
Campus del Camino de Vera
APDO 2012
Valencia 15

Tel. 369 67 00

Spanish Institute of Engineering
(Instituto de la Ingenieria de España)
38 General Arrando
Madrid

Ministry of Universities and Research
(Ministerio de Universidades e Investigación)
150 Serrano
Madrid

Tel. 261 54 00

Sweden

The Kingdom of Sweden occupies the eastern half of the Scandinavian peninsula and has borders with Norway and Finland. The principal services of the Government are centred in the capital, Stockholm.

Sweden is a member of the Nordic Council and academic qualifications obtained in any of the other Nordic countries (i.e., Denmark, Finland, Iceland and Norway) are recognized in Sweden. Candidates for academic positions from any of the five countries have equal status, preference being given to local candidates only if their qualifications are otherwise equivalent.

The position of sanitary engineer is not formally included in the public administration organization, but numerous engineers (civil, mechanical and chemical) operate at both public and private levels in the traditional fields of sanitary engineering and to some extent in the field of environmental health and protection.

University of Lund

Since 1975 an environmental studies programme has been offered jointly by the faculties involved in various aspects of environmental protection and management as well as in some aspects of human health protection.

The *Faculty of Civil Engineering, Department of Water Resources Engineering, Lund Institute of Technology (LTH),* a part of the University of Lund, organizes sanitary engineering training at three different levels:

(*a*) as part of the curriculum for graduation in civil engineering (water supply, wastewater treatment, limnology);

(*b*) for a Ph.D. degree in sanitary engineering;

(*c*) special courses (solid wastes management, treatment of industrial wastes).

The Department of Civil Engineering carries out an interdisciplinary activity in the field of environmental protection and management at the university level. The course lasts one academic year and entitles students to credits towards graduation from other technical and scientific faculties and towards a postgraduate diploma. The environmental studies programme also offers special courses, with lower qualifications, in environmental protection, industrial hygiene and solid wastes disposal. A seminar on urban water resources management was organized a few years ago under the sponsorship of UNESCO.

A postgraduate programme for industrial hygienists, started in 1983, includes a study of the health effects of the human environment. The programme is open to graduate chemists and chemical engineers.

The *School of Public Health* offers a postgraduate course and research programmes in the fields of air pollution, industrial hygiene, toxicology (with emphasis on environmental hazards) and radiation protection.

There ar no courses in sanitary engineering for physicians.

Royal Institute of Technology, Stockholm, and Chalmers University of Technology, Gothenburg

These are special institutions offering courses in the field of environmental protection. The courses are optional; this means that only a limited number of engineering students take them, due to the already considerable workload resulting from their ordinary studies. However, environmental topics are often integrated in the latter.

The departments of civil engineering at both institutions organize sanitary engineering training as part of the curriculum for graduation in civil engineering. By their choice of optional courses and degree projects, students can orient their studies during the third and fourth years towards different areas of application, such as pollution control engineering.

University of Umeå
At this University there is a special three-year public health and environmental protection programme for municipal health inspectors. Since under this programme students are given a broad environmental education, covering both natural and social sciences, they should be well qualified to deal with environmental matters in addition to health inspection tasks.

The University of Umeå also offers advanced and further education courses, e.g. in housing.

Luleå College and Institute of Technology
A four-year civil engineering programme in environmental planning and design is organized by this institution.

Other universities and colleges
In most places of higher education some basic courses in environmental protection are given; there are usually no formal requirements for participation. In Stockholm and Kalmar three-year programmes in environmental protection are offered.

Addresses

University of Lund
(Lunds Universitet)

Faculty of Medicine
School of Public Health
P.O. Box 1703
221 01 Lund

Lund Institute of Technology
(Lunds Tekniska Högskola)
Faculty of Civil Engineering

Chalmers University of Technology
(Chalmers Tekniska Högskola)
School of Civil Engineering
412 96 Gothenburg

Tel. (031) 81 01 00

Royal Institute of Technology
(Kungliga Tekniska Högskola)
School of Civil Engineering
100 44 Stockholm

Tel. (08) 787 00 00

University of Umeå
(Umeå Universitet)
Faculty of Medicine
901 87 Umeå

Tel. (090) 16 50 00

Luleå College and Institute of Technology
(Högskolan i Luleå)
951 87 Luleå

Tel. (0920) 910 00

Switzerland

The Swiss Confederation is situated in a mountainous area of central Europe, and is bounded by Austria, Italy, France and the Federal Republic of Germany. The country is a federal republic consisting of 26 independent cantons. Most administrative decisions are made at the canton level. The Federal Office of Public Health and the Federal Office for Environmental Protection have a largely advisory capacity. The two offices work to a large degree independently of each other: the former is medically oriented, while the latter has a strong engineering orientation.

The position of sanitary engineer is not formally recognized as such in the federal or cantonal administrations, although in practice there are

openings in public administration, engineering offices and research centres for graduates with the relevant skills.

Basic engineering is taught at the federal institutes of technology at Zurich (ETHZ) (in German) and at Lausanne (EPFL) (in French). At both institutes there are programmes leading to the diploma of civil engineer (*Dipl. Bauingenieur*) and environmental engineer (*Dipl. Kulturingenieur*) that contain material related to public health problems. Postgraduate engineering programmes are offered at both institutes. At ETHZ, the emphasis is on water and wastewater, while at EPFL more attention is given to environmental problems.

A new programme in environmental engineering at EPFL replaces that offered from 1972–1983, with additional emphasis on public and environmental health (see Part III). It is open to engineers, biologists, geologists and geographers. This new programme will produce sanitary engineers of the kind advocated by WHO. The training in sanitary engineering will be carried out in conjunction with the Swiss Tropical Institute in Basle, which will guarantee the quality of teaching in epidemiology, parasitology and hygiene. Each student will receive 520 hours of instruction (class-work, exercises and practical work) and carry out 9 months of research.

The University of Geneva offers an interdisciplinary environmental studies programme on a part-time basis for graduates in both human and natural sciences, with little emphasis on engineering.

The postgraduate programmes are attended by a large percentage of foreign students, but are not specially oriented towards the problems of developing countries.

The Swiss Federal Institute for Water Resources and Water Pollution Control (EAWAG) at Dübendorf near Zurich is primarily involved with research and teaching in water supply and water pollution control. Its various discipline-oriented groups (chemistry, biology, geology, engineering science) and problem-oriented groups (limnology, lake research, solid waste management, fisheries) are working mainly on problems related to industrialized countries. EAWAG also maintains a WHO collaborating centre for worldwide reference and coordination in wastes disposal, which concentrates its activities on the problems of liquid and solid waste disposal in developing countries.

Addresses

Federal Office of Public Health
P.O. Box 2644
3001 Berne
Tel. (031) 61 91 11

Federal Department of the Interior

Federal Office for Environmental Protection
3003 Berne
Tel. (031) 61 93 08

Federal Institute of Technology, Zurich (ETHZ)
Department of Rural Engineering
ETH-Hönggerberg
8093 Zurich

Tel. (01) 377 44 11

Swiss Federal Institute for Water Resources and Water Pollution Control (EAWAG)
8600 Dübendorf

Tel. (01) 823 55 11

Federal Institute of Technology, Lausanne (EPFL)
Department of Environmental Engineering
Ecublens
1015 Lausanne

Tel. (021) 47 11 11

University of Geneva
3 place de l'Université
1211 Geneva 4

Tel. (022) 20 93 33

Centre for Human Ecology
5 rue Saint Ours
1205 Geneva

Tel. (022) 20 93 33

Swiss Tropical Institute
Socinstraße 57
4051 Basle

Tel. (061) 23 38 96

Turkey

Part of the Republic of Turkey (Thrace) is in Europe and part (Anatolia) in Asia, the two parts being separated by the Bosphorus, the Sea of Marmara and the Dardanelles, which link the Black Sea to the Mediterranean Sea. Most of Turkey is in Asia, where it is bordered in the east by the Islamic Republic of Iran and the USSR and in the south by Iraq, the Syrian Arab Republic and the Mediterranean Sea. The small European part is bounded by Bulgaria and Greece.

Government services are centralized in the capital, Ankara, but municipal administrations have a high degree of independence. The position of sanitary engineer is not recognized as such, but engineers with training in the

basics of public health engineering are employed in government positions. The major emphasis has been on the development of adequate water supplies, not only in the cities but also in the rural districts, and training has laid more emphasis on the development and treatment of water than on other aspects of public health engineering.

With the Higher Education Law which came into effect in November 1981, all the institutions of higher education in Turkey, including the universities, have undergone a process of reform and structural reorganization. Accordingly, in addition to the already existing 19 universities, 8 new ones have been established. Responsibility for the coordination and planning of higher education has been vested in the newly established and fully autonomous Higher Education Council, which has 25 members and functions as a kind of national board of trustees.

All the universities are public institutions of higher education and are fully subsidized by the State. They enjoy full autonomy, which is also guaranteed by the Constitution and the Higher Education Law. Each university makes its own bye-laws and regulations without being subject to any interference or influence from outside. In questions relating to planning, development, capital investment and general higher education policies it cooperates with the Higher Education Council.

Environmental engineering study and research programmes are currently available at seven universities. The establishment of one other programme is still in the planning stage pending the Higher Education Council's decision.

The Department of Environmental Engineering of the Faculty of Engineering at the Middle East Technical University in Ankara offers full-time courses at graduate and undergraduate levels. Instruction is in English. (See Part III.) The postgraduate programme was developed in collaboration with WHO and WHO sponsors a collaborating centre for community water supply and wastes disposal in the Sanitary Engineering Laboratory of the Middle East Technical University.

The Department of Environmental Engineering of the Faculty of Civil Engineering at the Technical University of Istanbul offers full-time courses at graduate and undergraduate levels. WHO, in cooperation with UNDP, has funded a 10-year programme to upgrade the environmental engineering programme at the Technical University of Istanbul. Instruction is in Turkish.

Dokyz Eylül is one of the eight new universities established in 1982 and, like Ege University, is located in Izmir. Environmental engineering, previously associated with Ege, has been assigned to Dokyz Eylül and consists of graduate and undergraduate programmes. Instruction is in Turkish.

The Department of Environmental Engineering of the Institute of Sciences at Çukurova University in Adana offers only graduate courses. Research projects are also funded. Instruction is in Turkish.

The Water and Environment Programme of the Institute of Sciences, Yildiz University, Istanbul, offers graduate courses in Turkish.

The Institute of Environmental Studies, Bogazici University, Istanbul, offers graduate courses in English.

The Department of Environmental Biology, Institute of Sciences, Istanbul University, offers ecological studies at the graduate level in Turkish.

At Atatürk University, Erzurum, the establishment of a department of environmental studies and engineering in the Faculty of Engineering is planned.

Addresses

Middle East Technical University
(Orta Docu Teknik Üniversitesi)
Faculty of Engineering
Inönü Bulvri
Ankara

Tel. 23 71 00

University of Çukurova
(Çukurova Üniversitesi)
Balcali Campus
Adana

Tel. 20 373

Atatürk University
Environmental Problems Research Institute
(Atatürk Üniversitesi
Cevre Sorunlar Arastirma Enstitüsü)
Erzurum

Tel. 14 120/1245 or 1346

Bogazici University
University of the Bosphorus
Institute of Environmental Studies
P.K. 2, Bebek
Istanbul

Tel. (9011) 65 34 00

Technical University of Istanbul
(Istanbul Technik Üniversitesi)
Environmental (Sanitary) Engineering Department
Maslak
Istanbul

Tel. 43 31 00

University of Istanbul
(Istanbul Üniversitesi)
Beyazit
Istanbul

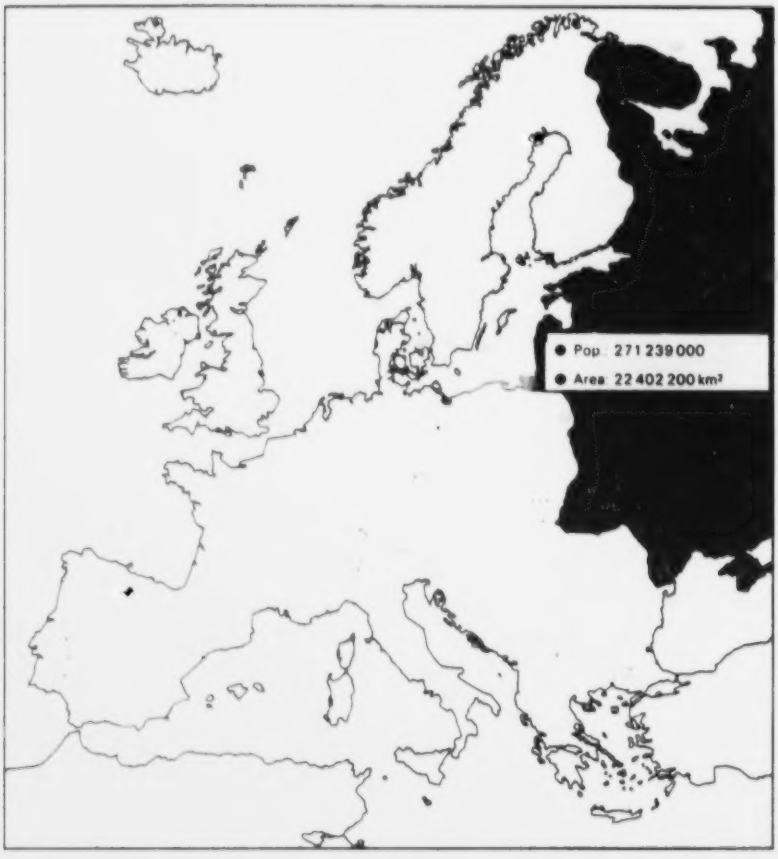
Tel. (9011) 23 85 31

Istanbul State Academy of Engineering and Architecture
(Istanbul Devlet Mühendislik ve Mimarlik Akademisi)
Yildiz
Istanbul

Tel. 61 02 20

Dokyz Eylül University
(Dokyz Eylül Üniversitesi)
Department of Environmental Engineering
Faculty of Architecture and Engineering
Cumhuriyet Bulvari
Alsancak — Izmir

Tel. 21 10 10/21 55 90



Union of Soviet Socialist Republics

The Union of Soviet Socialist Republics (USSR) stretches from the Baltic Sea in the west to the Pacific Ocean in the east. In Europe the USSR has borders with Norway, Finland, Poland, Czechoslovakia, Hungary and Romania, while in Asia it is bounded by Turkey, the Islamic Republic of Iran, Afghanistan, China, Mongolia and the Democratic People's Republic of Korea.

At present, engineers are trained at 238 higher educational establishments in 20 specialties in accordance with the requirements of the national

economy. (Some of the leading institutions offering training in engineering are listed below.)

The postgraduate training of engineers in sanitation and environmental protection is carried out at a number of technical higher educational establishments, for example at the Leningrad, Rostov and Byelorussian universities (departments of mechanics and mathematics), the Moscow and Leningrad mining institutes and the Leningrad Technological Institute of the Wood Pulp and Paper Industry.

Postgraduate training for sanitary engineering specialists is also provided at a number of institutes associated with certain branches of industry. The Kiev Institute for the Postgraduate Training of Managers and Specialists for Municipal Public Utilities is a leading establishment in this field.

In 1978, Soviet higher educational establishments trained 39 500 engineers for work in sanitary engineering; this represents an increase of 11.5% compared with the figure for 1975. Since then many more engineers in this specialty have graduated annually from higher educational establishments.

In recent years the following specialized areas have been established, among others:

— collection and utilization of dust and gases

— rational use of water resources and decontamination of industrial liquid waste

— water supply in rural areas, water supply development and protection of water resources

— use of gas and fuel oil and air protection.

Although specialists in these areas are not formally called sanitary engineers, the curriculum for their training includes basic knowledge of the fundamentals of hygiene, microbiology and ecology.

A large number of sanitary engineers work in the sanitary and epidemiological service of the USSR. The specialized and postgraduate education of these engineers is provided in the sanitation and hygiene departments of institutes for advanced medical studies.

The sanitary and epidemiological stations (*sanepids*) of the republics and the authorities at the various administrative levels form an important part of the service, whose functions are prescribed in the legislation. Their duties include all aspects of environmental and workers' health.

The sanitary and epidemiological service, headed by the Deputy Minister of Health of the USSR (the Chief State Medical Officer of Health), is also organized according to territorial and administrative divisions. There is a central service in the Ministry of Health, and similar services exist in the ministries of health of each republic. In addition, the *sanepids* form the basic unit of the service in republics, regions, districts, towns, and marine and river basins. These stations supervise measures relating to the health protection of the environment and the prevention of communicable and occupational diseases. There are more than 4000 such stations, each equipped with its own hygiene and bacteriological laboratory and staffed by specialists in various disciplines, such as public health physicians, epidemiologists, bacteriologists,

biologists and engineers. These experts specialize in various branches of hygiene, such as communal, food, industrial, and child and adolescent hygiene. The stations also have middle-level and junior medical staff.

The chief physician of a *sanepid* is the chief state medical officer of health of the corresponding territorial unit. The training of physicians is subdivided according to branches and is conducted in various faculties.

The activities of the sanitary and epidemiological service are a good example of professional cooperation between sanitary physicians and technical specialists working in non-medical branches of the national economy.

From its very inception the sanitary and epidemiological service of the USSR has cooperated with a large number of engineering organizations and bodies in solving various public health and environmental protection problems. The basis of joint and concerted action between the sanitary and epidemiological service and engineering organizations is to be found in the legislation relating to public health and sanitation.

In the course of time, the requirements for professional cooperation between medical and technical specialists have become more stringent. Of importance also is the question of determining the volume of teaching material on hygiene, public health organization fundamentals and some theoretical medical disciplines in the (sanitary) engineering curricula, in both undergraduate and postgraduate education.

The training of specialists capable not only of solving environmental protection problems but also of controlling the environment with the aim of improving it calls for changes in the education pattern. It is necessary, in particular, to improve the biological and medical knowledge of engineering specialists, including sanitary engineers. In order to implement this objective, complex plans for continuing training in ecology for students in all specialties have been developed by higher educational establishments. Beginning with the 1980–1981 school year, systematic training for students in the field of environmental protection and the utilization of natural resources has been introduced as part of the standard curriculum at all higher educational establishments.

There are some facilities for training foreign students in the USSR, in particular at the M.I. Kalinin Polytechnic Institute, Leningrad. Instruction is given in Russian.

The Academy of Communal Economy, Moscow, is a WHO collaborating centre for community water supply and wastes disposal.

The Central Institute for Advanced Medical Studies, Moscow, is a valuable source of information regarding the training of specialists in public health engineering in the USSR.

Addresses

Universities

Byelorussian V.I. Lenin State University
Universitetsky Gorodok
Minsk

Kiev T.G. Shevchenko State University
Vladimirskaya Ul. 64
Kiev

Tel. 208 691

Leningrad A.A. Zhdanov State University
Universitetskaya Nab. 7/9
Leningrad B-164

Rostov Mikhail Suslov State University
Ul. Fridrikha Engelsa 105
344711 Rostov-on-Don

Technical institutes

Belgorod Civil Engineering Institute
Ul. Gorkogo 56
Belgorod

Brest Civil Engineering Institute
Moskovskaya ul. 267
Brest 17

Gorky V.P. Chkalov Civil Engineering Institute
Ul. Krasnoflotskaya 65
Gorky

Kharkov Civil Engineering Institute
Ul. Sumskaya 40
Kharkov

Kiev Civil Engineering Institute
Vozdukhoflotsky prosp. 99/101
Kiev 37

Kuibyshev A.I. Mikoyan Civil Engineering Institute
Ul. Molodogvardeyskaya 194
Kuibyshev

Leningrad Civil Engineering Institute
Ul. Krasnoarmeyskaya 4
Leningrad

Leningrad G.V. Plekhanov Mining Institute
21 Liniya 2
Leningrad V-26

Leningrad Technological Institute of the Wood Pulp and Paper Industry
Ul. Ivana Tchernych 4
Leningrad

All-Union Extramural Civil Engineering Institute
Ul. Srednyaya Kalitnikovskaya 30
Moscow

K.D. Pamfilov Academy of Municipal Economy
Volokolamskoe Shosse 116
Moscow 123 373

Moscow Mining Institute
Leninsky Prospekt 6
Moscow M-19

Penza Civil Engineering Institute
Ul. Titova 28
Penza

Odessa Civil Engineering Institute
Ul. Didrikhsona 4
Odessa

Poltava Civil Engineering Institute
Prospekt 1 Maya 24
Poltava

Volgograd Civil Engineering Institute
Ul. Akademicheskaya 1
Volgograd

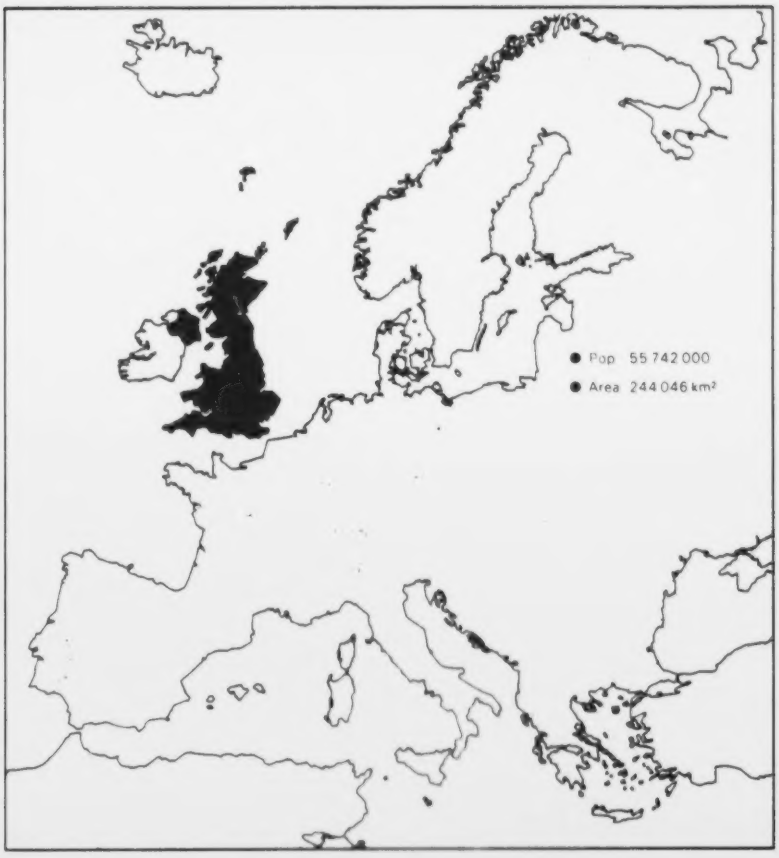
Voronezh Civil Engineering Institute
Ul. 20-letiya Oktyabrya 84
Voronezh

Other addresses

Ministry of Health of the USSR
Rahmanovskij pereulok 3
101431 GSP Moscow K-51

Central Institute for Advanced Medical Studies
Research Department of Scientific Principles of Postgraduate Education
Pl. Vosstania 1/2
Moscow 123 242

Academy of Communal Economy
Moscow 123 373



United Kingdom

The United Kingdom consists of the island of Great Britain, Northern Ireland, and a number of islands off the northern and north-western coasts. Great Britain is divided into England in the south, Wales in the west and Scotland in the north. The capital and the seat of government is London, but for administrative purposes England, Scotland, Wales and Northern Ireland are usually treated separately.

The universities have independent status and award degrees and diplomas that are subject to control by their own internal academic organizations. Polytechnics are to some extent responsible to their local authorities and

award certificates, diplomas and degrees at various levels; the degrees are subject to national central control by the Council for National Academic Awards, which supervises curricula and standards. There is free interchange of students' credits between all academic institutions in the United Kingdom.

In the United Kingdom the term "public health engineer" is preferred to its essential equivalent, sanitary engineer. Although "public health engineer" is not a post title in public service, a great many such engineers are employed in public, institutional and commercial establishments. A number of professional associations and institutions count public health engineers among their members, including the Institution of Civil Engineers, the Institution of Public Health Engineers, the Institution of Water Engineers and Scientists and the Institute for Water Pollution Control.

A large number of engineering schools offer a few undergraduate courses in the public health aspects of civil engineering, but in general these do not account for more than 10–20% of the three-year studies. An exception is the University of Newcastle-upon-Tyne, where it is possible to take an option in which the whole of the final (third) year is devoted to public health engineering.

There are also a few public health engineering courses in the undergraduate programmes for chemical engineers. An engineer intending to devote his professional career to public health engineering is more likely to take one of the postgraduate Master's or diploma courses.

A list of institutions offering advanced degrees or diplomas in various aspects of public health engineering in the United Kingdom is given in the table opposite.

An annual calendar of courses on water at universities and polytechnics in Great Britain is issued by J. Pickford, Loughborough University of Technology. The book "Higher education in the United Kingdom 1982–84: a handbook for students and their advisers", published for the British Council and the Association of Commonwealth Universities by Longman, London, has sections devoted to engineering, public health and industrial health. The Institution of Civil Engineers publishes a "Guide to continuing education courses for civil engineers" three times a year. This guide lists only courses available for the current term.

A survey by Ives (see footnote, p. 113) gave an estimate of the significance of different parts of the programmes at the various institutions. Very large parts of the curricula included the traditional content of water-based sanitary (public health) engineering: design of water treatment and wastewater treatment, water supply and wastewater disposal, etc. They also included waterborne diseases, and water and wastes chemistry. Significant parts of the curricula included most of the supporting sciences, such as biology and microbiology, ecology, analytical chemistry, biochemistry, sanitation and environmental health. In addition, they covered systems analysis, administration and law, hydraulics, re-use, technology applicable to developing countries, and solid wastes. Minor parts of the curricula included the sciences of hygiene, toxicology, epidemiology, parasitology, radiation protection, public health legislation, and land and buildings. All of the

Institutions in the United Kingdom offering advanced degrees or diplomas in public health engineering[a]

Institution	Degree offered	Subject(s)
Universities		
Aston at Birmingham	M.Sc./Diploma	Environmental sciences/ occupational health and hygiene/water resources technology
Dundee	MPH	Public health
Leeds	M.Sc.	Environmental pollution control
Liverpool	M. Community Health	Community hygiene
London		
• Imperial College	M.Sc./Diploma	Public health engineering/ environmental technology
• London School of Hygiene and Tropical Medicine	M.Sc./Diploma	Community health in developing countries
• University College	M.Sc.	Environmental engineering in architecture
Loughborough	M.Sc./Assoc.	Water and waste engineering
Newcastle-upon-Tyne	M.Sc./Diploma/Cert.	Public health engineering/water resources/environmental design
Nottingham	M.A.	Environmental planning for developing countries
Salford	M.Sc.	Environmental resources
Strathclyde	M.Sc./Diploma	Public health engineering/ environmental engineering
Polytechnics		
Middlesex (London)	Diploma (part-time)	Air and water pollution control
North East London	Diploma	Water resources engineering
Sheffield City	Diploma (part-time)	Water engineering and pollution control/chemical pollution monitoring
Other institutions		
Water Research Centre	Certificate of attendance at seminars and conferences	Water and waste

[a] Information based on the survey "Public health component of sanitary engineers' training curricula situation in the United Kingdom, October 1982", by K.J. Ives, Professor of Public Health Engineering, University College, London, United Kingdom (unpublished document ICP/EHP 001(1)/12, WHO Regional Office for Europe, Copenhagen) and supplemented from other sources.

air-related topics and the subprofessional subjects of plumbing, heating and ventilation, were in this group.

None of the curricula included noise control, food control or hospital architecture. The overall picture that emerges from this survey is that the postgraduate courses in the United Kingdom are principally traditional in content, with a water-based sanitary (public health) engineering programme. The emphasis on engineering is evident, and the public health components (biological, medical) are of secondary importance, acting as service courses to the major engineering content. (See Part III, programme at Imperial College, London.)

In addition to offering an essentially traditional public health engineering programme, a number of institutions have specialized programmes with a significant content of public health engineering. Several institutions have courses or whole programmes directed to the needs of students from developing countries. For example, Loughborough University of Technology has an M.Sc. programme in water and waste engineering for developing countries (see Part III). This is a 12-month programme which may, if necessary, be preceded by a one-year pre-M.Sc. programme for students with inadequate background education. The courses are in English. The London School of Hygiene and Tropical Medicine has close ties with public health engineering institutions and is especially concerned with the public health problems of developing nations. It provides teachers for public health courses at other institutions. The Universities of Leeds and Loughborough also have faculty members with special expertise in the problems of developing countries.

The Department of Civil Engineering at the Imperial College of Science and Technology, London, offers short-term training opportunities in industrial wastewater treatment, air pollution control, solid wastes management, water supply and sanitation in developing countries, advanced aspects of water and wastewater management, water-related tropical diseases, wastewater treatment, water quality management and water treatment.

A number of universities and polytechnics have programmes related to environmental problems; these programmes include some material with a public health content. Many of the courses deal with the relationships between different environmental topics, for example, land disposal of sludge from sewage, air pollution from wastes incineration, and leachate pollution of groundwater resulting from the dumping of toxic chemicals.

In September every year, teachers of public health engineering in universities and polytechnics meet at a different university or polytechnic to discuss matters of common interest, both formally and informally. These meetings are used, among other things, for teachers to inform each other of curriculum material, and in a small way this helps to "train the teachers" in new developments. For example, at Warwick University in 1982, Mr Pickford (Loughborough University) dealt with aspects of the International Drinking Water Supply and Sanitation Decade that could be incorporated into teaching; at Leeds in 1980, Dr Feachem (London School of Hygiene and Tropical Medicine) outlined the engineer's role in defeating water-related (not just waterborne) diseases.

WHO sponsors collaborating centres at three locations in the United Kingdom: the Ross Institute (the TUC Centenary Institute) of the London School of Hygiene and Tropical Medicine, on water-related diseases (infectious diarrhoeas); the University of Newcastle-upon-Tyne, on community water supply; and the Medmenham Laboratory of the Water Research Centre (WRC), on drinking-water and water pollution control. The WRC also sponsors conferences and seminars on various aspects of water supply and pollution control, including such subjects as the health aspects of spreading sludge on land.

Addresses

Universities

University of Aston in Birmingham
Faculty of Engineering
Gosta Green
Birmingham B4 7ET

Tel. 021 359 36 11

University of Dundee
Faculty of Engineering and Applied Science
Dundee DD1 4HN

Tel. 0382 23181

University of Leeds
Faculty of Engineering
Leeds LS2 9JT

Tel. 0532 431751

University of Liverpool
Faculty of Medicine
P.O. Box 147
Liverpool L69 3BX

Tel. 051 09 6022

University of London
Faculty of Engineering
Senate House
London WC1E 7HU

Tel. 01 636 8000

Imperial College of Science and Technology
Department of Civil Engineering
South Kensington
London SW7 2AZ

Tel. 01 589 5111

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University College
Department of Civil and Municipal Engineering
Gower Street
London WC1E 6BT

Tel. 01 387 7050

London School of Hygiene and Tropical Medicine
(incorporating the Ross Institute and
the TUC Centenary Institute)
Keppel Street
London WC1E 7HT

Tel. 01 636 8636, ext. 203

Loughborough University of Technology
School of Engineering
Loughborough
Leicestershire LE11 3TU

Tel. Loughborough 63171

University of Newcastle-upon-Tyne
Faculty of Engineering
Newcastle-upon-Tyne NE1 7RU

Tel. Newcastle 328511

University of Nottingham
Faculty of Engineering
University Park
Nottingham NG7 2RD

Tel. 0602 56101

University of Salford
Salford
Lancashire M5 4WT

Tel. 061 736 5843

University of Strathclyde
School of Civil and Mining Engineering
George Street
Glasgow G1 1XW

Tel. 041 552 4400

Polytechnics

Middlesex Polytechnic
Faculty of Engineering Science and Mathematics
Admissions Office
114 Chase Side
Southgate
London N14 5PN

Tel. 01 886 6599

North East London Polytechnic
Faculty of Engineering
Romford Road
Stratford
London E15 4LZ

Tel. 01 555 0811

Sheffield City Polytechnic
Faculty of Engineering
Pond Street
Sheffield S1 1WB

Tel. 0742 20911

Water Research Centre:

WRC Environmental Protection
Medmenham Laboratory
P.O. Box 16
Henley Road
Medmenham
Marlow
Buckinghamshire SL7 2HD

Tel. 0491 571 531

WRC Process Engineering
Stevenage Laboratory
Elder Way
Stevenage
Hertfordshire SG1 1TH

Tel. 0438 2444

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WRC Engineering Centre
P.O. Box 85
Frankland Road
Blagrove
Swindon
Wiltshire SN5 8YR

Tel. 0793 488301

Other institutions

Institution of Civil Engineers
Great George Street
London SW1P 3AA

Tel. 01 222 7722, ext. 211

Institution of Public Health Engineers
13 Grosvenor Place
London SW1X 7EN

Tel. 01 245 9778

Institution of Water Engineers and Scientists
31–33 High Holborn
London WC1V 6AX

Tel. 01 831 6578

Institute for Water Pollution Control
Ledson House
53 London Road
Maidstone
Kent ME16 8JH

Tel. 0622 62034

Yugoslavia

The Socialist Federal Republic of Yugoslavia, which comprises the republics of Serbia, Croatia, Macedonia, Montenegro, Slovenia and Bosnia-Herzegovina, is situated along the east coast of the Adriatic Sea and has borders with Italy, Austria and Hungary in the north, Romania and Bulgaria in the east, and Greece and Albania in the south.

The Federal Committee for Labour, Health and Social Welfare is the federal administration body in charge of activities in the field of health.

Higher education at the university level is coordinated by the Federal Secretary for Information, but the individual republics control the language of instruction. The principal language, Serbo-Croatian, is widely used

throughout the country, but engineering instruction is also given in Slovenian and Macedonian at Ljubljana and Skopje, respectively.

The education of various categories of technical staff (sanitary technicians, laboratory technicians, etc.) includes training in the field of sanitation at the appropriate secondary and two-year postsecondary schools.

Sanitary engineering is taught in the hydrotechnical departments of universities (Belgrade, Zagreb, Ljubljana, Sarajevo, Rijeka and Split) to students wishing to become engineers in this particular field.

At some faculties of medicine (Belgrade, Zagreb and Ljubljana) it is possible to specialize in this subject during postgraduate studies and acquire the title of specialist in sanitary engineering and health architecture. The same faculties offer the possibility of obtaining Master's and Doctor's degrees in the fields of environmental protection and sanitary engineering.

In Zagreb, the Andrija Štampar School of Public Health, an integral part of the Faculty of Medicine, offers a programme of postgraduate studies in the fields of ecology, chemistry, the environment, amelioration, health architecture, engineering, etc.

Addresses

University of Belgrade
Studentski Trg 1
11000 Belgrade

Tel. 011 635 153

Faculty of Civil Engineering
Bulevar Revolucije 73

Tel. 011 338 661

Faculty of Medicine
Pasterova 6

Tel. 011 684 998

Centre for Multidisciplinary Studies
Sl. Penezic-Krcuna 35

Tel. 011 681 466

"Edvard Kardelj" University of Ljubljana
Faculty of Agriculture, Civil Engineering and Geodesy
Trg Osvoboditve 11
Ljubljana

Tel. 214 212

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University of Rijeka
Faculty of Engineering
Trg Rijecke Rezolucije 7/1
51000 Rijeka

Tel. 38-51 25-682

"Kiril i Metodije" University of Skopje
Faculty of Civil Engineering
Bulevar Krste Misirkov BB
91000 Skopje

Tel. 058 49966

University of Split
Faculty of Civil Engineering
Livanska 5/1
58000 Split

Tel. 058 49966

University of Zagreb
Faculty of Civil Engineering
Trg Marsala Tita 14
P.O. Box 815
41000 Zagreb

Tel. 041 272 411

Andrija Štampar School of Public Health
Medical Faculty, University of Zagreb
Rockefellerova 4
41000 Zagreb

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II. International organizations

A number of international organizations concern themselves with the training and qualifications of engineers and technicians, including sanitary and public health engineers. Within the United Nations family of organizations the following take an active part in such training, in addition to WHO: UNESCO, the World Bank, UNDP and UNEP. Other international organizations involved include the Council of Europe, CMEA, FEANI, OECD, and NATO.

The World Health Organization (WHO)

The World Health Organization, with headquarters in Geneva, has six regional offices. The Regional Office for Europe serves the needs of 33[a] Member States.

The Environmental Health Service of the Regional Office for Europe, Copenhagen, is divided into units covering (*a*) basic sanitation (water supplies, waste disposal, housing and settlements); (*b*) environmental pollution (air, water and radiation); (*c*) environmental systems management (toxicology, epidemiology and environmental health impact); (*d*) food safety (additives and contaminants); (*e*) occupational health; and (*f*) planning, services and training.

The WHO fellowships programme provides opportunities for training and study in health matters which are not available in the candidate's own country, and also enables the international exchange of scientific knowledge and techniques relating to health.

The major fields in which fellowships are awarded are: public health administration, environmental health (sanitation, housing, town planning and food control), nursing, medicosocial work, maternal and child health, other health subjects, communicable diseases, laboratory services, clinical medicine, basic medical sciences, and medical and allied education.

The fellowships programme is administered by the various regional offices. In recent years, some 20% of the fellowship awards to candidates

[a] See footnote, p. ix.

from the European Region were for studies in environmental sanitation. Large numbers of fellows come to European centres from other regions. In 1982 the leading European host countries, in order of the number of fellows accepted, were the United Kingdom, France, the USSR, the Federal Republic of Germany, the Netherlands and Switzerland.

Other WHO activities connected with the training of sanitary engineers have included the programme leading to the publication of this directory. Special week-long seminars, such as one on the health aspects of treated sewage re-use, Algiers, 1980[a] serve to up-date engineering education. Such seminars are usually presented as part of a country or regional project, although they may draw observers from other countries and regions.

The United Nations Educational, Scientific and Cultural Organization (UNESCO)

UNESCO has published eight volumes in a series *Standards in engineering education*, some of which are available also in French and Spanish, as follows.

1. *Standards for engineering qualifications/Normes de qualifications des ingénieurs* (1975), a comparative study in 18 European countries, prepared by FEANI

2. *Social sciences and humanities in engineering education/Rôle des sciences sociales et humaines dans la formation des ingénieurs/Las ciencias sociales y humanidades en la formación de ingenieros* (1974)

3. *The continuing education of engineers/La formation continue des ingénieurs* (1975)

4. *Staff development for institutions educating and training engineers and technicians* (1977), a study dealing with the special problems of developing countries

5. *The design of engineering curricula/La elaboración de los planes de estudio de ingeniería* (1975) (to appear also in French)

6. *Advances in continuing education* (1980) (to appear also in French)

7. *Engineering technicians: some problems of nomenclature and classification* (1981)

8. *Strengthening cooperation between engineering schools and industry* (in preparation)

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[a] *Health aspects of treated sewage re-use:* report on a WHO Seminar. Copenhagen, WHO Regional Office for Europe, 1980 (EURO Reports and Studies, No. 42).

9. *The environment in engineering education* (1980)

With the exception of No. 9, dealing with environmental engineering, none of the studies lays particular stress on the public health aspects of engineering, and even in the last volume the emphasis is primarily on the aspects of environmental and workers' health.

The World Bank (the International Bank for Reconstruction and Development (IBRD))

The World Bank operates the Economic Development Institute (EDI), which provides training for government officials at the middle and upper levels of responsibility who are concerned with development programmes and projects. Courses are in national economic management and project analysis, and are given in Washington, DC and overseas, in English, French or Spanish. Although many of the courses are designed for managers, there is a strong sanitary engineering component.

The United Nations Development Programme (UNDP)

UNDP is the world's largest agency for technical cooperation and a major source of funds for projects sponsored by the World Bank. It offers support for professional vocational training, predominantly in developing countries.

The United Nations Environment Programme (UNEP)

UNEP administers a fund to provide voluntary additional financing for new environmental initiatives. Its Global Environmental Monitoring Programme (GEMS) includes training for operators of monitoring equipment. Meetings are held with the United Nations Economic Commission for Europe (ECE) to enable UNEP to pass on to the developing countries the experiences gained by the industrialized countries in their own development.

The Council of Europe

The Council of Europe in Strasbourg has a strong environmental programme, sponsors education in environmental understanding, and is a supporter of the Foundation for Environmental Education in Europe.

The Council for Mutual Economic Assistance (CMEA)

CMEA, with headquarters in Moscow, has a Permanent Commission on Public Health and a Standing Conference of Chiefs of Water Resources Authorities. Its International Centre for Scientific and Technological Information develops methods and technical aspects of information work and provides an information service for the participating countries.

The European Federation of National Associations of Engineers (FEANI)

FEANI, whose headquarters are in Paris, studies problems involved in training of engineers, is active in setting standards for engineering qualifications and was responsible for preparing the first volume of the UNESCO series (see above), a generalized report which does not treat sanitary engineers as a special category.

The Organisation for Economic Co-operation and Development (OECD)

OECD, with headquarters in Paris, sponsors a Development Centre to bring together the knowledge and experience available in member countries regarding both economic development and the formulation and execution of general policies of economic aid, to adapt such knowledge and experience to the actual needs of developing countries, and to place the results at the disposal of these countries by appropriate means.

The North Atlantic Treaty Organization (NATO)

NATO, with headquarters in Brussels, has a Committee on the Challenges of Modern Society (CCMS), whose task is to examine methods of improving member countries' cooperation aimed at creating a better environment. The Committee sponsors NATO advanced study institutes on various aspects of public health and environmental engineering. Each institute provides intensive courses in a particular aspect of engineering which also serve to up-date background training.

III. Representative training programmes for sanitary engineers

Algeria

Undergraduate programme in sanitary engineering
Houari Boumedienne University of Science and Technology, Algiers

Prerequisites: Six semesters at the University in the undergraduate programme in civil engineering; knowledge of French

Duration: The last four of ten semesters

Language: French

Degree: Sanitary engineer

Courses:

		Hours
Seventh semester		
7.1	The aquatic environment	140
7.2	Health legislation	—
7.3	Underground hydrology	75
7.4	Urban hydrology	60
7.5	Pumping-stations, pipes	75
7.6	Sanitary engineering structures	75
Eighth semester		
8.1	Environmental microbiology	90
8.2	Unit operations, physicochemical	120
8.3	Measurement and regulation	60
8.4	Systematic analysis	60
8.5	Urban and domestic hygiene	45

		Hours
Ninth semester		
9.1	Water supply for single dwellings	30
9.2	Unit operations, biological and sanitary engineering	90
9.3	Solid wastes	60
9.4	Air pollution	45
9.5	Nutrition and food safety	45
9.6	Public health and sanitary legislation	120
9.7	Management and financial analysis	45
9.8	General economics	45
Tenth semester		
10.1	Legislation on water and the environment	30
10.2	Conferences	30
10.3	Final project	—

Czechoslovakia

Undergraduate programme in water technology and the environment
Faculty of Civil Engineering, Slovak Technical University, Bratislava

Prerequisites: Three years of general studies in civil engineering

Duration: Five years

Language: Slovak

Degree: Civil engineer; Specialist in water technology and the environment

Courses:

1. Ecology
2. Hydrochemistry
3. Hydrobiology
4. Microbiology
5. Toxicology
6. Water technology
7. Hydrology and meteorology
8. Water economics
9. Creation and protection of the environment

10. Energetics

11. Introduction to the theory of human environment and health protection at work, comprising engineering psychology, human environment, working conditions, health protection and safety at workplaces (45 hours) (compulsory for all engineering students)

France

Postgraduate programme
National School of Public Health, Rennes

Prerequisites: Degree in engineering (in most cases)

Duration: One year (two semesters = 1035 hours)

Degree: Diplôme d'ingénieur du Génie sanitaire de l'ENSP

Courses:

		Hours
1.	Public health and epidemiology	
1.1	General principles of public health	9
1.2	Epidemiological techniques	27
2.	Basic science (including 70 hours' practical work)	
2.1	Water chemistry	54
2.2	Microbiology	75
2.3	Toxicology	12
3.	Practice of sanitary engineering and environmental hygiene (including 36 hours' practical work, special projects and plant units)	
3.1	Hydrology applied to sanitary engineering	48
3.2	Potable water	57
3.3	Wastewater	66
3.4	Disposal of solid wastes	21

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		Hours
3.5	Recreational waters (4 conferences)	—
3.6	Protection of the environment	42
	3.6.1 The lithosphere	—
	3.6.2 The hydrosphere	—
	3.6.3 The atmosphere	18
3.7	Physical pollutants	39
	3.7.1 Radiation	18
	3.7.2 Noise	21
3.8	Town planning, hygiene and dwellings	27
3.9	Disinfection of rooms and hospital hygiene	15
4.	Training in applications and administration	
4.1	Data processing	84
	4.1.1 Mathematical statistics	57
	4.1.2 Computers	27
4.2	General and public health administration	51
	4.2.1 French administrative law	15
	4.2.2 General accounting	6
	4.2.3 Departmental accounting	6
	4.2.4 Administrative correspondence	12
	4.2.5 Environmental law	12
4.3	Health education (seminars)	30

Federal Republic of Germany

Undergraduate programme in sanitary engineering
Faculty of Civil Engineering, University of Stuttgart

Prerequisites: Graduation from secondary school (*Gymnasium*)

Duration: Four years (eight semesters)

Degree: Diplom-Ingenieur

Basic lectures, obligatory for all students of civil engineering (fifth and sixth semesters):

- Water supply
- Wastewater collection and disposal
- Solid wastes collection and disposal

Lectures for students specializing in sanitary engineering (seventh and eighth semesters):

- Water resources management
- Water treatment
- Design of water supply systems and water treatment plants
- Wastewater treatment
- Industrial wastewater treatment
- Advanced wastewater treatment
- Design of wastewater collection systems and wastewater treatment plants
- Pipelines and pumping stations
- Chemistry of water and wastewater (laboratory course)
- Microbiology of water and wastewater (laboratory course)

Quantity and quality of solid wastes
Solid wastes treatment and disposal
Sludge treatment

Optional courses:

Water chemistry I, II
Well construction
Treatment of special solid wastes of industrial origin
Principles of limnology
Industrial hygiene and health protection
Hygienic aspects of water supply and waste disposal
Legal and administrative aspects of water supply and waste disposal

Hungary

Postgraduate programme in water supply, sewerage and sanitary engineering
Faculty of Civil Engineering, Technical University of Budapest

Prerequisites: Degree in engineering

Duration: Two years (four semesters)

Courses:

	Hours	
	Optional	*Compulsory*
First semester		
1. Water chemistry, water hygiene	2	20
2. Wastewater chemistry	2	25
3. Applied hydrology (underground water)	2	25
4. Hydromechanics	2	20
5. Economic planning	—	10
Second semester		
1. Applied hydraulics	12	14
2. Applied hydrology (surface water)	8	14
3. Deep wells	12	14
4. Water supply and water treatment I	10	42
5. Environmental health I	10	20
6. Health organization and administration	—	10

	Hours	
	Optional	*Compulsory*
Third semester		
1. Environmental health II	5	20
2. Biology	3	30
3. Water supply and water treatment II	18	30
4. Sewage treatment	20	25
5. Economy and state management of water supplies	—	10
Fourth semester		
1. Epidemiology	5	20
2. Occupational health	10	20
3. Water supply and water treatment III	10	25
4. Wastewater treatment	10	25
5. Food hygiene	—	10
6. Technology of environmental health plants	10	20

Italy

Postgraduate programme in sanitary engineering
Faculty of Engineering, University of Naples

Prerequisites: Graduation with a degree in engineering equivalent to M.Sc.

Duration: One academic year (about seven months)

Degree: Specialist in sanitary engineering

Courses:

	Hours
Principles of biology	30
Principles of microbiology	20
Chemistry of fermentation	20
General hygiene	20
Industrial and occupational hygiene	20
Housing, urban hygiene and hospital engineering	25
Environmental pollution control	30
Water chemistry (20 hours plus 30 hours' laboratory)	50
Hydrology	15
Water resources management	15
Water technology	15
Aqueducts and sewerage works design	30
Water and wastewater treatment plant design (50 hours plus 70 hours' exercises)	120

	Hours
Town and country planning	25
Air conditioning	20
Complementary subjects:	
Atmospheric pollution	10
Solid wastes disposal and treatment	10
Systems analysis	10
Legislation	4
Applied economics	6

Morocco

Undergraduate programme in sanitary engineering
Department of Environmental Engineering,
Mohammedia School of Engineering (EMI),
Mohammed V University, Rabat

Prerequisites: Two years of preparatory studies at the University

Duration: Three years

Language: French

Degree: Environmental engineer

Courses:

		Hours
1.	Reinforced concrete structures	50
2.	Applied hydraulics	30
3.	Urban hydraulics: water and sewerage systems	50
4.	Treatment of potable water: sources, treatments, stabilization, re-use, laboratory work, plan of a water purification plant	55
5.	Wastewater treatment: treatments, chlorination, criteria for discharges, sludge treatment and disposal, protection of receiving waters, visits to plants, design of a treatment plant	70

		Hours
6.	Solid wastes: sanitary requirements for collection, treatment and disposal of garbage and other wastes	15
7.	Mathematical statistics	20
8.	Computer programming	20
9.	Administration and finance	20
10.	Ecology: population dynamics, food chains, pollution	40
11.	Sanitary chemistry: analyses, coagulation, laboratory exercises	60
12.	Sanitary microbiology: microorganisms of water, enzymes, effects of discharges; air, soil and food microbiology	50
13.	Quality of the environment water quality, standards for air and food; workers' environment, toxic substances, air pollution	20
14.	Principles of epidemiology: virulence, transmissible diseases, disinfection, control of rats and insects, special problems in tropical climates	30
15.	Parasitology and control of vectors: intestinal protozoa, blood parasites, malaria, mycoses, insecticides, fumigation, molluscicides	30
16.	Food hygiene	20
17.	Rural sanitation: sources of water for domestic and animal use; sewers and drainage, latrines, septic tanks; legislation; camping and bathing areas	
18.	Public buildings: hygiene, indoor climate; hospitals, schools, abattoirs	20
19.	Water resource management	50
20.	Administration of public health and environmental hygiene	15
21.	Public health education	10
22.	Special projects	405

Netherlands

Postgraduate programme in sanitary engineering for developing countries
International Institute for Hydraulic and Environmental Engineering (IHE), Delft

Prerequisites: Engineers (civil, agricultural, chemical or mechanical) with at least three years of practical experience

Duration: One academic year (10½ months)

Language: English

Degree: Diploma equivalent to M.Sc., or Certificate of Attendance

General subjects:

Review of sanitary engineering
General chemistry
Organic chemistry
Microbiology
Hydrobiology
Limnology
Chemistry and microbiology of water and sewage
Radioactivity
Waterborne diseases
Applied hydraulics
Statistics
General hydrology
Urban hydrology

Introduction to the computer
Computer programming

Technical subjects:

Water distribution
Wastewater collection
Groundwater flow, recovery and recharge
Intake and impounding of surface water
Pumps and mechanical equipment
Water treatment plants
Sanitary engineering construction
Agricultural waste
Waste disposal at sea
Solid wastes collection and disposal

Unit operations:

Screening and mechanical disintegration, aeration and gas transfer, sedimentation, flotation, rapid filtration, slow sand filtration, microstraining, chemical coagulation, water softening, water stabilization, disinfection, chlorination, ozonation, adsorption, trickling filters, activated sludge, oxidation ditches, stabilization ponds, sludge treatment and disposal, desalination, reverse osmosis

Broad-based subjects:

Management of water resources
Urban planning aspects of water pollution control
Project management
Control and automation
Thermal pollution
Engineering operations
Systems analysis

Additional for programme I (industrial areas):

Atmospheric pollution
Radioactive waste
Industrial waste
Advanced wastewater treatment methods

Additional for programme II (rural areas):

Public health administration
Determinants of health and disease
Special topics on public health
Selected subjects in water supply

Portugal

Postgraduate programme in sanitary engineering
New University of Lisbon

Prerequisites: Diploma from an institution of higher education, professional experience and prospects of employment in the field of sanitary engineering; knowledge of English and French

Duration: 15 months

Language: Portuguese, some courses in English and French

Degree: Specialist in sanitary engineering

Courses:

		Hours
1.	Ecology	
1.1	General ecology	20
1.2	Ecology of inland waters	20
1.3	Marine ecology	14
1.4	Soil ecology	10
1.5	Microbiology	70
1.6	Management of hydrological resources	14
1.7	Water pollution	30
1.8	Air pollution	10
2.	Electromechanical equipment	80
3.	Hydraulics	130

143

		Hours
4.	Hygiene	
4.1	Introduction: hygiene of dwellings	17
4.2	Comfort and hygiene of buildings	16
4.3	Introduction to industrial hygiene	10
4.4	Problems of sanitation in urban and rural structures	18
5.	Applied mathematics	130
6.	Unit operations	
6.1	Basic treatment techniques	90
6.2	Surveillance of industrial effluents	20
6.3	Conversion and ultimate disposal of solid wastes	14
6.4	Recovery of wastes	16

Switzerland

Postgraduate programme in environmental engineering
Federal Institute of Technology, Lausanne
(Ecole polytechnique fédérale, Lausanne (EPFL))

Prerequisites: An undergraduate degree in engineering or science equivalent to that obtained at EPFL; excellent knowledge of French, with reading knowledge of English and/or German

Duration: One calendar year

Degree: Certificate of completion of course in environmental engineering

Courses:

1. Environmental engineering — 71 hours
   - 1.1 Economics and financial planning
   - 1.2 Application of systems theory to the environment
   - 1.3 Environmental sociology
   - 1.4 Environmental law and legislation
   - 1.5 Application of legislation on environmental protection in Switzerland
   - 1.6 Hydrology and epidemiology
2. Biological engineering — 42 hours
   - 2.1 Nature and composition of organic wastes
   - 2.2 Bioconversion of organic wastes

3. Chemical pollution — 50 hours

- 3.1 Chemical theories and the environment
- 3.2 Study of pollutants
- 3.3 Effects of chemical pollutants
- 3.4 Industrial pollution
- 3.5 Effects of chemical pollutants on agriculture
- 3.6 Environmental hygiene and workers' health

4. Ecological sciences — 43 hours

- 4.1 Fundamental ecology
- 4.2 Freshwater ecology
- 4.3 Ecology of the marine environment
- 4.4 Impact of certain installations on the natural environment

5. Mathematics of the environment — 51 hours

- 5.1 Descriptive statistics
- 5.2 Mathematical statistics
- 5.3 Analysis of data
- 5.4 Optimization

6. Field trips, special reports, research project — 17 weeks

Turkey

Undergraduate programme in environmental engineering
Department of Environmental Engineering, Middle East Technical University, Ankara

Prerequisites: Admission to the University; good knowledge of English (courses are taught in English)

Duration: Four years

Degree: Environmental engineer

Courses:

		Hours
First three semesters: basic engineering courses		174
Fourth semester		
4.1	Introduction to environmental microbiology	12
4.2	Environmental chemistry II	12
4.3	Introduction to computers and programming	9
4.4	Mathematics for engineers	9
4.5	Strength of materials	9
Fifth semester		
5.1	Physical principles of environmental engineering	9
5.2	Material science	9
5.3	Soil mechanics	9
5.4	Introduction to fluid mechanics	9

		Hours
5.5	Engineering hydrology	9
5.6	Statistical methods in engineering	9
Sixth semester		
6.1	Chemical microbiology	12
6.2-6.3	Unit operations and processes in environmental engineering I and II	18
6.4	Hydromechanics	9
6.5	Surveying and engineering measurements	9
6.6	Environmental chemistry III	12
6.7	Environmental sanitation	9
Seventh semester		
7.1	Environmental modelling	9
7.2	Principles of ecology	9
7.3	Water and wastewater engineering	9
7.6	Unit operations and processes laboratory	9
7.7	Water resources engineering I	9
7.8	History of the Turkish Revolution	—
Eighth semester		
8.1	Solid waste management	9
8.2	Water quality management	9
8.3	Air quality management	9
8.4	Water and wastewater engineering design	9
8.5	Water resources engineering II	9
8.6	Surface chemistry (elective)	9
8.7	History of the Turkish Revolution	—

United Kingdom

London: Imperial College

Postgraduate programme in public health and water resource engineering
Department of Civil Engineering, Imperial College of Science and Technology, London

Prerequisites: Good honours degree or equivalent in civil, chemical or environmental engineering

Duration: One year

Language: English

Degree: M.Sc. in public health engineering

Courses:

Principles of public health
Urban and groundwater hydrology
Applied chemistry
Applied bacteriology
Water and wastewater analysis
Water and wastewater treatment in hot climates
Water supply
Advanced wastewater treatment
Air pollution
Solid waste management
Statistics
Systems in water management

(The period from Easter to September is devoted to individual projects and visits to industrial and research establishments.)

Unit processes

Sedimentation, flocculation, filtration, fluidization, microstraining, flotation

Gas transfer

Aerobic biological processes

Anaerobic biological processes

Sludge treatment

Water supply

Estimation of supply

Sources

Treatment sequences

Distribution

Wastewater treatment

Flow estimation

Separate and combined systems

Treatment sequences

Sludge disposal

(There are other courses which deal with fluid-particle mechanics, flow in channels, pipes and networks, groundwater flow and river pollution control.)

United Kingdom

London: University College

Undergraduate programme in public health engineering
University College, London

Prerequisites: This programme is one of twelve options, six of which must be taken in the final year of studies for the degree of B.Sc. in civil engineering, together with some compulsory subjects

Duration: Time allotted: 46 hours' lectures, 9 hours' laboratory work

Language: English

Degree: B.Sc.

Courses:

Elementary aquatic biology

Microorganisms:

discovery; physiological classification; growth requirements; metabolism and biochemistry; genetic aspects

Bacteria:

growth kinetics; water-related diseases; water examination and treatment; sewage treatment

Viruses, higher bacteria, fungi, algae:

distribution and significance in health; treatment processes

Higher plants:

control in new reservoirs, eutrophication

Protozoa:

ecology and health significance; role in treatment processes

Metazoa:

growth in pipes

Helminths, Crustacea, insects:

health significance; treatment processes

Water chemistry

Equilibrium and kinetics, stoichiometry

Decomposition and synthesis:

role of oxygen, BOD, aerobic and anaerobic reactions, organic carbon, nitrogen and sulfur cycles

Disinfection:

chlorine, chlorinated compounds, ozone, ultraviolet

Hardness and alkalinity, pH, precipitation

Ion exchange

adsorption processes

Reactor theory

Colloids:

electrical and molecular forces, perikinetic flocculation, mineral salts (aluminium, ferric), polyelectrolytes

Radioactivity in water

Standards

Analytical methods

United Kingdom

Loughborough

Postgraduate programme in water and waste engineering for developing countries
Department of Civil Engineering, University of Technology, Loughborough, Leicestershire

Prerequisites: Good honours degree and at least two years' relevant practical experience; good knowledge of English

Duration: One year (starting 1 October)

Language: English

Degree: M.Sc. in water and waste engineering

Courses:

Water resources management:

groundwater location and abstraction; hydrology; water quality; irrigation; hydraulics and hydraulic structures; water management

Water supply engineering:

water requirements; rural water supply; urban water supply; transmission, storage and distribution; prevention of corrosion; operation and maintenance

Health, waste and the community:

tropical health and disease; integrated rural and urban development; unsewered sanitation; sullage disposal; solid wastes collection, treatment and disposal; air pollution

Wastewater treatment and disposal:

sewerage and drainage; microbiology and chemistry; conventional treatment plants; low-cost treatment units; industrial discharges; land treatment

Finance and management:

organizational structures and problems; financial management and control; management methods; project identification, appraisal and implementation; development economics; project and contractual management

United Kingdom

Newcastle-upon-Tyne

Postgraduate programme in public health engineering
Department of Civil Engineering, University of Newcastle-upon-Tyne

Prerequisites: Good honours degree in engineering

Duration: Twelve months (starting 1 October); may be taken in four modules, each lasting five weeks, plus research project and dissertation over a three-year period

Language: English

Degree: M.Sc.

Courses:

Majors

1. *Aquatic sciences course:* physical, chemical and biological examination of waters and wastewaters; introduction to aquatic chemistry and biology

2. *Water supply engineering:* biological aspects of water supply; examination of water treatment; physical and chemical processes in water treatment; design hydraulics and pipeline engineering

3. *Wastewater engineering:* biology of waste treatment; biochemistry; engineering aspects of waste treatment; treatment and disposal of industrial wastes

Minors

1. *Elements of public health:* history of public health; epidemiology and vital statistics; food and nutrition; housing; occupational hygiene; control of disease and disease vectors

2. *Environmental sanitation:* atmospheric pollution; refuse disposal; radioactivity; water supply and waste disposal in tropical countries

3. *Advanced design:* use of mathematical techniques of simulation and optimization for design and operation in wastewater treatment and pollution control

4. *Elements of water resource administration:* analytical, legal and administrative aspects of water resources, with particular reference to England and Wales (subjects studied include hydrology, management techniques and economics)

The M.Sc. consists of the three majors, plus two minors: either (*a*) Elements of public health and Environmental sanitation, or (*b*) Advanced design and Elements of water resource administration.

United States

Johns Hopkins University

Graduate programme in sanitary engineering
School of Hygiene and Public Health, Johns Hopkins University, Baltimore, MD

Prerequisites: Degree in engineering

Course no.		*Credits*
18M01	The environment	5
18A11	Municipal sanitation	4
18A12	Vector control	4
18A13	Air pollution control and strategy	4
18A14	Air pollution and industrial hygiene laboratory	4
18A15	Airborne particulates	3
18A16	Research methods in environmental microbiology	4
18A17	Seminar in environmental health	2
18B17	Seminar in environmental health	2
18A18	Environmental law	3
18A19	Administration of environmental health services	3
18A21	Environmental health field work	to be arranged
18A22	Industrial ventilation	4
18A23	Occupational safety management	3
18A24	Legal and social implications of environmental health programs	3

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Course no.		*Credits*
18A25	Principles of industrial hygiene	2
18A27	Analytical methods in environmental engineering	3
18A28	Instrumental analysis in environmental engineering	4
18A29	Safety and health research laboratory	2
18A29A	Industrial hygiene and safety by process and operations	2
18A29B	Human factors engineering	2
18A90	Physical and biological effects of air pollutants	4
18A220	Issues in environmental health management	2
18A221	Principles of occupational safety	2

United States

University of North Carolina

Graduate programme in sanitary engineering
School of Public Health, University of North Carolina,
Chapel Hill, NC

Prerequisites: Degree in engineering

Course no.		*Credits*
ENVR 122	Water chemistry	4
ENVR 123	Organic materials in natural waters	3
ENVR 131	Biology in environmental science	3
ENVR 132	Limnology and water pollution	3
ENVR 143	Applied physiology and toxicology	3
ENVR 144	Air pollution measuring, monitoring and survey	3
ENVR 145	Instrumentation and data acquisition	3
ENVR 146,L	Industrial hygiene engineering, control, design, lab.	3,1
ENVR 171	Water quality evaluation and control	3
ENVR 174,L	Water and wastes treatment processes, lab.	3,1
ENVR 183	Specialized topics in water resources	2
ENVR 217	Systems analysis in environmental planning	3
ENVR 218	Environmental systems analysis I	3
ENVR 241	Mechanics of aerosols	3,1
ENVR 242	Industrial hygiene practices	3
ENVR 243	Air and its contaminants	3
ENVR 245	Air pollution control	3

Course no.		*Credits*
ENVR 247	Chemistry of the troposphere	3
ENVR 248	Industrial medicine	3
ENVR 249	Air pollution meteorology	3
ENVR 271	Modelling in natural aquatic systems	3
ENVR 272	Water supply, wastewater disposal systems	3
ENVR 273	Wastewater treatment plant design	3
ENVR 274	Advanced wastewater treatment processes I	3
ENVR 275	Advanced wastewater treatment processes II	3
ENVR 276	Industrial water quality management	3
ENVR 277	Engineering project design	3
ENVR 278	Development of a water project	3
ENVR 281	Advanced hydrology	3
ENVR 283	Natural resource law, policy	3

Courses outside the Department

BIOS 105	Principles of statistical inference	3
BIOS 135	Probability and statistics	4
BIOS 145	Principles of experimental analysis	3
EPID 162	Epidemiology for environmental and occupational health	3

United States

University of Illinois

Graduate programme in sanitary engineering
University of Illinois, Urbana-Champaign, IL

Prerequisites: Degree in engineering

Duration: Three years

Course no.	
CE 340	Physical principles of environmental engineering processes
CE 341	Air resources monitoring
CE 342	Water quality control processes
CE 343	Chemical principles of environmental engineering processes
CE 344	Solid waste monitoring
CE 345	Atmospheric dispersion modelling
CE 346	Biological principles of environmental engineering processes
CE 347	Aquatic ecology
CE 349	Air resources engineering
CE 358	Air pollution and combustion
CE 395	Application of modelling in public systems
CE 398EW	Ecology and monitoring of inland waters
CE 440	Water treatment processes
CE 442	Wastewater treatment processes
CE 443	Unit operations in environmental engineering
CE 444	Treatment of industrial wastes
CE 445	Modelling of operation of water quality systems
CE 446	Design of water and waste treatment plants

Course no.	
CE 448	Control of air pollution
CE 495G	Environmental engineering seminar
CE 495AG	Advanced environmental engineering seminar
CE 497	Independent study
CE 498AC	Advanced aquatic chemistry
CE 498WQ	Deterministic water quality modelling
CE 499	Thesis research

Recommended elective courses

Course no.	
CE 352	Water resources design
CE 353	Analysis and design of hydraulic systems
CE 356	Hydraulics of surface drainage
CE 357	Groundwater
CE 452	Water resources
BIOCH 350	General biochemistry
CH E 381	Chemical rate processes and reactor design
CHEM 328	Principles of environmental chemistry
CHEM 329	Instrumental methods in environmental science
CHEM 340	Principles of physical chemistry
MCBIO 309	Comparative microbial chemistry
MCBIO 409	Cultivation and properties of microorganisms

IV. Consultation on the public health component of sanitary engineers' training curricula: report on a WHO meeting

1. Introduction

A Consultation was convened in the WHO Regional Office for Europe in Copenhagen, from 8 to 10 November 1982, to prepare detailed recommendations regarding the public health, biological and medical components of the training curricula of sanitary engineers in the European Region.

The meeting was opened by Dr A. Wojtczak, Director, Research, Planning and Human Resources, who stated that the regional strategy for attaining health for all by the year 2000 recognizes primary health care as a key component and that this includes nutrition, environment, education and agriculture as well as medicine. The training of sanitary engineers is a part of health manpower development, which is an integral part of the strategy. It is essential to provide public health training for engineers, so that public health issues can be dealt with from an engineering and professional point of view. Dr Wojtczak referred briefly to the sanitary engineering training programmes at Delft, Lausanne, Rabat and Warsaw.

Professor L.Y. Maystre and Professor M.S. Hilbert were elected Chairman and Vice-Chairman respectively; Professor K.J. Ives was elected Rapporteur.

Mr E. Giroult, Regional Officer for Environmental Health Planning and Management, outlined the subject-matter to be considered. In broad terms, this was:

(*a*) the health-related content of sanitary engineering training curricula;

(*b*) the improvement of communication, through training, between public health medical doctors and sanitary engineers;

(*c*) the orientation of sanitary engineering training programmes in Europe towards engineering solutions of public health problems.

2. Scope and purpose

The scope was defined as the training curricula in sanitary engineering programmes which apply a public health approach to sanitary engineering. The task of the sanitary engineer was defined: "To adapt man's environment

by engineering means to the requirements of his health". This concept was to be applied to public health and not the personal health of the individual. Biomedical engineering (dealing with prosthetic devices, artificial kidney machines, hospital, surgical and medical equipment) was excluded from consideration, as was biotechnology in the production of pharmaceuticals, chemicals, etc., except where there was a public health significance, e.g. in effluents from biotechnology.

The purpose of the meeting was to prepare recommendations regarding the public health, biological and medical components of the training curricula of sanitary engineering programmes. These components would be in accordance with the public health role of sanitary engineering and would look to future requirements.

3. Educational concepts

Due to the variety of educational systems which exist in the European Region, it is not possible to identify a single model of the education of a sanitary engineer. In some cases, sanitary engineering topics are taught at undergraduate level; in others, they are first introduced at postgraduate level. However, for all the educational systems, about four to five years of education beyond the secondary school level are required.

Most sanitary engineers have a civil engineering background, although some have initial training as agricultural, chemical or mechanical engineers. Normal training of all engineers comprises mathematics, chemistry, physics, electrical technology, material properties, structures, solid and fluid mechanics, economics, measurement and design.

Normal training for sanitary engineers includes technical aspects of water management and supply, wastewater collection and disposal, air pollution control, solid waste management and other engineering installations and operations.

In addition to these technical aspects, there is a public health dimension in these various contacts of man with water, land, air, radiation, noise and biosphere. The health dimension in sanitary engineering curricula is aimed at benefiting man's health. In this context, health is taken as the WHO definition: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity".[a]

The Consultation participants therefore decided to concentrate on the health components of training, leaving aside the technical aspects. In considering the health components, they agreed that the training programmes should impart to the students:

— knowledge

— skills

— attitudes.

Attitudes towards the importance of health-related topics cannot be taught, but are imparted by the teachers' enthusiasm, professional

[a] Constitution of the World Health Organization.

commitment and explanations of the relevance of the contents of the curricula. Participation of teachers from medicine and other health professions would be vital and would improve communication between public health medical doctors and sanitary engineers. Likewise, the importance of health-related topics needs to become a conviction on the part of the teachers of sanitary engineering.

4. Requirements of the graduate

4.1 Employment areas

Evidence from several countries in the European Region showed that the professional sanitary engineer is employed in the following areas:

- central government
- local government (community authorities, water authorities, etc.)
- consulting practices
- industry (including those which develop public health equipment and construct installations)
- teaching and research.

The relative importance of these varies between countries. For example, governmental agencies are the principal employers in France; in the Federal Republic of Germany, although governmental agencies employ over 50% of sanitary engineers, the consulting practices are significant; in the USSR, engineers are technical advisers to physicians in the management of the system of sanitary-epidemiological services.

Many European sanitary engineers are employed in developing countries or their work is directed to problems of developing countries, e.g. British engineers in the British Commonwealth and French-speaking engineers in the francophone countries of Africa and Asia.

It was concluded, therefore, that, in addition to health-related topics valid for the European Region, some training in tropical health was necessary.

4.2 Basic competence

Although the sanitary engineer should be capable of dealing with the health dimension of his professional work, he will still be expected to be competent in his role as an engineer. He may be expected to collaborate effectively with biologists, chemists, medical doctors and other health personnel, and to appreciate and act on the health consequences of an engineering intervention. Nevertheless, he will still be expected to be able to design, execute, supervise and inspect engineering installations relating to sanitary engineering.

4.3 New activities

The strong interest in protecting the environment which has developed in the past 15 years has placed new responsibilities on the sanitary engineer. Although these have been modifed by the worldwide energy crisis and

economic recession, occasional man-made and natural disasters bring reminders that vigilance is needed.

Toxicological problems of solid waste disposal, contamination of land, water and air and the production of new industrial products often demand engineering solutions. New developments require environmental impact statements. Oil exploration and exploitation pose new hazards. Public concern with radiation hazards and noise nuisance often demands engineering intervention. These and other developments are discussed in the working papers by Professor K.J. Ives and Professor M.S. Hilbert (see Annexes 1 and 2 respectively).

The International Drinking Water Supply and Sanitation Decade has initiated great activity in developing countries and has created a general awareness of public health problems associated with water and waste disposal.

The Consultation referred to these new activities, noting that they placed extra requirements on the health-related curricula of sanitary engineering programmes. WHO was also concerned, for example, in helping with environmental health impact assessment studies.

5. Fields of activity

In order to determine the most relevant public health topics, a number of fields of activity were considered. These are listed in section 10. The list is not intended to be exhaustive but covers water (including wastewater), solid wastes, land and soil, atmospheric topics, urban and rural areas, buildings, recreation, entertainment and tourism, noise, radiation and public health aspects of food.

This represented a problem-orientated approach, which followed logically from the previous consideration of the requirements of the graduate. Each of the fields of activity was evaluated in terms of the needs:

— to identify the health implications

— to decide standards to be achieved

— to assess the health effects of the engineering intervention.

These evaluations were made asking the question, "What does the sanitary engineer need from public health subjects to carry out his tasks?". It was assumed that, where necessary, he would be working with professional chemists, biologists, medical personnel, etc. For example, in the case of the field of activity of supply of palatable and wholesome drinking-water (section 10, item 1), the following public health subjects were involved:

— sanitary biology and microbiology

— waterborne diseases

— epidemiology

— biostatistics

— principles of toxicology

— principles of human physiology

— public health and environmental legislation.

Again, for example, in the field of collection and disposal of solid industrial wastes (section 10, item 8), the following public health subjects were involved:

- vector control
- determinants of health and disease related to air (air hygiene)
- urban sanitation
- epidemiology
- parasitology
- urban determinants of health and disease (urban hygiene)
- housing determinants of health and disease (housing hygiene)
- principles of toxicology
- toxicological chemistry
- public health and environmental legislation.

5.1 Common public health subjects

It can be seen from these two examples that there are common public health subjects in three rather disparate fields of activity:

- epidemiology
- principles of toxicology
- public health and environmental legislation.

By following this scheme of evaluation, a matrix was created of the fields of activity and the public health subjects which produced the 28 topics listed in section 11. The topics most frequently arising are the eight marked with an asterisk, namely:

- epidemiology
- parasitology
- principles of human physiology
- principles of toxicology
- public health and environmental legislation
- sanitary biology and microbiology
- vector control
- waterborne diseases.

These were common for most fields of activity of sanitary engineering and therefore could be considered the most relevant.

6. Curriculum topics

An initial list of curriculum topics (comprising about 90 subjects) was taken from the consultant report by Professor L. Mendia.[a] Many of these were in the technical area of sanitary engineering, but the topics in section 11 are mostly included in the initial list.

The Consultation concluded that the remaining 20 topics of section 11 (i.e. those not marked with an asterisk) should be considered as optional. The topics selected should depend on the employment envisaged for the sanitary engineering graduate. Other constraints may also affect the choice, depending, for example, on the resources of the training establishment.

Certain terms from the initial list were redefined to make the title more appropriate. Where this has happened, the old title appears in brackets. The new definitions appear at the end of section 11.

No attempt was made by the participants to detail the course content to be covered by the titles in section 11. It was felt that this would be more appropriately done by teachers who are experts in the various subjects in the training establishments.

7. Training of teachers

In order to encourage the public health orientation in sanitary engineering training programmes, the Consultation recommended that WHO organize a summer-school type of course for teachers of sanitary engineering in the European Region. This should include instruction, particularly in the newer health-related topics, to train the teachers as well as promote a health-orientated attitude.

8. Conclusions

(1) The scope of the Consultation was the training curricula in sanitary engineering programmes which apply a public health approach to sanitary engineering.

(2) The task of sanitary engineering was defined as: "To adapt man's environment by engineering means to the requirements of his health".

(3) The purpose of the Consultation was to prepare detailed recommendations regarding the public health, biological and medical components of sanitary engineers' training curricula, in accordance with the public health role of sanitary engineering.

(4) The Consultation considered that the training programmes should transfer:

— knowledge (*savoir*)
— skills (*savoir–faire*)
— attitudes (*savoir–être*)

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[a] **Mendia, L.** *Study of availability and content of environmental health courses in Europe.* Copenhagen, WHO Regional Office for Europe, 1982 (unpublished document ICP/EHP 002).

(5) It was assumed that engineers have a basic training in engineering (mathematics, chemistry, physics, electrical technology, material properties, structures, solid and fluid mechanics, economics, measurement, design) and would come principally from a civil engineering background, although some could be agricultural, chemical or mechanical engineers.

(6) It was also assumed that sanitary engineering training as such would include technical aspects of water management and supply, wastewater disposal, air pollution control, solid waste management and other engineering installations and operations. This allowed the recommendations to concentrate on the health components of training.

(7) The employment of sanitary engineers was considered to be based in central and local governments, consultancy, industry, teaching and research. The relative importance of these areas varies from country to country. For example, in France, governmental agencies are the principal employer, while in the USSR engineers are advisers on technical problems to physicians in the management of the system of sanitary–epidemiological services. Many European engineers work in developing countries.

(8) A number of fields of activity were identified as being relevant (section 10). These were evaluated in terms of needs:

— to identify the health implications

— to establish standards

— to assess the health effects of the engineering intervention.

(9) The 90 curriculum topics from the consultant report by Professor L. Mendia[a] were classified by their application to:

— human health

— processes and engineering installations

— the environment and nature.

(10) The list of 26 curriculum topics from (9) above, plus two more, which were considered as relating to human health is given in section 11.

(11) Certain words were newly defined and the list in section 11 is in terms of the new definitions, with the old titles shown in brackets. It was recognized that in some teaching programmes certain words were given different meanings. Therefore, the definitions which appear in section 11 were adopted.

(12) The fields of activity, referred to in (8) above, were examined by the criterion: "What does the sanitary engineer need from public health subjects

[a] **Mendia, L.** op. cit.

to carry out his task?". This produced eight major curriculum components. Obviously, these are common for most fields of activity of sanitary engineering and therefore could be considered the most relevant. The remaining 20 were less frequently required and therefore could be considered as optional but relevant and often desirable.

9. Recommendations

(1) International recognition should be accorded only to those sanitary (or public health) engineering courses in Europe which stress public health in their curriculum.

(2) Collaboration with the network of European environmental health engineers and scientific training institutions should be maintained in order to develop continuing education of these professionals at national and international level.

(3) All sanitary (public health) engineering training institutions in Europe should be encouraged to revise their curricula in accordance with the conclusions and training recommendations of this Consultation.

(4) A refresher course on public health matters for sanitary engineering teachers in Europe should be organized in 1984–1988 in order to promote the recommendations of this report.

(5) The Directory of Sanitary Engineering Courses in Europe should include two main parts: the first giving broad information on the situation with regard to the training of environmental health engineers and scientists in each country of the Region; the second giving detailed information on existing courses of international significance, this information being needed by fellowship officers among others.

(6) Training programmes for sanitary engineering should contain curriculum components based on public health topics, to enable sanitary engineers to apply a health approach to their professional work.

(7) The public health curriculum components, as indicated in conclusion (12) above and in section 11, should accompany the normal technical subjects which are necessary to the planning, design, construction and operation of sanitary engineering installations.

(8) The public health components should include appropriate education in knowledge, skills and attitudes. The latter, in particular, which are important to a health orientation, should be provided by contact with teachers from medicine and other health professions. The content of other public health components of the curriculum may also benefit from contact with teachers from medicine and other health professions.

(9) Public health components to be selected should depend on the professional employment envisaged for the sanitary engineering graduate.

(10) The public health components which should be considered most relevant (marked with an asterisk in section 11) are:

- epidemiology
- parasitology
- principles of human physiology
- principles of toxicology
- public health and environmental legislation
- sanitary biology and microbiology
- vector control
- waterborne diseases.

10. Fields of activity relating to the tasks of the sanitary engineer

(1) Supplying palatable and wholesome drinking-water

(2) Supplying water for non-domestic purposes

(3) Collecting, treating and disposing of liquid domestic waste

(4) Collecting, treating and disposing of liquid trade waste

(5) Managing quality of fresh surface-waters

(6) Managing quality of coastal and estuarine waters

(7) Collecting and disposing of solid domestic wastes

(8) Collecting and disposing of solid industrial wastes

(9) Managing quality of the soil

(10) Managing quality of underground waters, springs and wells

(11) Collecting and treating gaseous discharges

(12) Managing quality of the atmosphere

(13) Integrated rural sanitation

(14) Managing habitats of disease vectors

(15) Sanitary inspection of dwelling houses

(16) Sanitary inspection of city planning

(17) Sanitary inspection of public buildings (e.g. schools, prisons, barracks, markets, places of entertainment)

(18) Design and control of swimming pools

(19) Control of noise

(20) Managing of consequences of natural and man-made disasters

(21) Integrated management of environmental health in a city or region

(22) Control of slaughterhouses and meat processing

(23) Sanitary control of milk processing and distribution

(24) Sanitary control of foodstuffs and food storage and processing

(25) Radiation control

(26) Toxic wastes control

(27) Management of sanitation of touristic complexes

11. Curriculum components relating to human health[a]

Biostatistics

Determinants of health and diseases related to air (air hygiene)

Determinants of health and disease applied to sanitary engineering (applied hygiene)

* Epidemiology

Environmental determinants of health and disease (environmental hygiene)

Food determinants of health and disease (food hygiene)

Health (of public) control on working premises

Housing determinants of health and disease (housing hygiene)

Human ecology

Industrial determinants of health and disease (industrial hygiene)

Industrial toxicology

Noise control

* Parasitology

[a] Topics marked with an asterisk are those which occur the most frequently in curricula.

* Principles of human physiology
* Principles of toxicology
* Public health and environmental legislation

  Public health education

  Public health organization and administration

  Radiation protection

  Rural sanitation
* Sanitary biology and microbiology

  Toxicological chemistry

  Tropical determinants of health and disease (tropical hygiene)

  Urban determinants of health and disease (urban hygiene)

  Urban ecology

  Urban sanitation
* Vector control
* Waterborne diseases

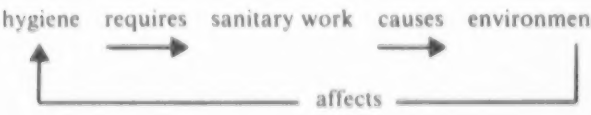
Definitions

Hygiene: concern with physical, chemical, biological, geographical and social environmental determinants of health and disease.

Sanitary: relates to installations or processes, therefore has a technical content, implying hardware.

Environment: Global and local surroundings, including nature.

These may be linked in a cyclic or feedback manner:



Applied: must be used as applied *to* something, for example microbiology applied to sanitary engineering, ***not*** applied microbiology.

Control: management in some cases, for example, environmental quality management, rather than environmental quality control.

Annex 1

PUBLIC HEALTH COMPONENT OF SANITARY ENGINEERS' TRAINING CURRICULA

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1. Introduction

In 1970, WHO published a book entitled "The education and training of engineers for environmental health" *(1)*. That book was the outcome of a report *(2)* of an Expert Committee convened in 1967 to review the subject. (The recommendations of that report are reproduced, for information, in Appendix 1; it is not particularly useful to review items as they are rather general in nature.) Those publications were intended to update the guidelines for engineering education in environmental health which had appeared in an even earlier monograph in 1956 on the training of sanitary engineers *(3)*.

The argument in the 1967 Expert Committee report was that both the scope of environmental health and the education of engineers had developed dramatically in the previous decade and new requirements and opportunities had arisen. These were discussed in the 1970 book under three principal headings:

— the work of the environmental health engineer

— trends in modern engineering education

— new developments in environmental health engineering.

Eleven essays explored various topics under these headings. On the whole, these essays were commentaries in special fields (mathematics, systems analysis, design, social science, computers, epidemiology, instrumentation) and somewhat exhortative to those who prepare and teach engineering curricula. The chapter by J.A. Logan entitled "Trends in environmental health engineering education" particularized most, by quoting a list of recent developments in engineering education from the 1967 Expert Committee report.

This list included references to the greater scientific, rather than applied, content of basic engineering educational programmes. This scientific content itself was based on school-level fundamental science, which was growing less compartmentalized and traditional. The list recognized a more analytical approach to design and decision-making, which with the aid of computers had enabled systems to be planned in a more coherent way than previous methods of linking unit operations. Engineers had to be not only more technically competent but also more aware of the social implications

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of their work. New educational facilities, such as miniaturized laboratory equipment, programmed learning, information storage and retrieval, were recognized. The need for advanced and continuing education for engineers was stressed. It was concluded that, in addition to the humanities and social sciences, all engineers should have a fundamental background in mathematics and statistics, physical sciences and engineering sciences (solid and fluid mechanics, materials, thermodynamics and electrical science).

That fundamental background seems quite acceptable, as it is a restatement of what has been included in university engineering programmes for decades. However, the list reiterated by J.A. Logan included the statement that all environmental health engineers should, in addition, study systems analysis, epidemiology, biology (including physiology), biochemistry and management (including policy, law, administration and finance). This is a most controversial statement requiring the engineer to be educated in fields of other professional specializations for which he may not have had sufficient background training. The statement also refers to "an environmental health engineer", previously defined by J.A. Logan as one who must deal with the environment as a system, controlling, modifying or adapting it in the interest of the wellbeing of mankind. (This definition followed closely a similar one in the 1967 Expert Committee report.)

It is a pity that the imaginative and rather idealistic requirements of this definition, the list of the trends in education, and the specialized essays of the 1970 book were not met by the examples of educational programmes given in the final part of the book. With the exception of the American examples (Berkeley, Chapel Hill), the curricula appeared to be traditional in the sanitary engineering mode. It is not clear whether the examples were typical or exceptional in the regions which they represented. However, it must be remembered that these documents, emanating from WHO Geneva, had to take into account the global situation. There are still many areas of the world where conditions of primitive water supply and sanitation and relatively uncontrolled industrial development still require engineers and others trained in traditional skills, without the perception and resources of engineers operating exclusively in the sophisticated societies of highly industrialized countries.

However, that was the case in the late 1960s. The Expert Committee report of 1967 and the book of 1970 were attempting to set guidelines for the final three decades of the twentieth century. Some of the trends have, indeed, now developed further: computer technology, computerized data bases which are accessible worldwide, regionalization of water management, and international cooperation in monitoring, standards and development. In addition, the revolution in environmental awareness has promoted public interest and participation in areas that were traditionally only the remit of conservationists and ecologists; energy management has become a prime concern of governments and industry; biotechnology has emerged with its attendant servant, genetic engineering.

It is a useful time to take stock of developments in the last one and a half decades and to establish for the European Region what should be the public health component of sanitary engineers' training curricula.

2. The environmental revolution

2.1 The Club of Rome and after

It was Rachel Carson's "Silent spring" *(4)*, first published in 1962, which aroused public interest during the 1960s in the damaging effects of pollution of the environment. The Club of Rome's publication "Limits to growth" *(5)*, which appeared in the early 1970s, took an even wider view and saw environmental pollution as one aspect of a rape of the world's resources, both those that were being unrenewably utilized and those that were being irreversibly polluted. A spate of publications followed, some dealing with global society, even advocating an abandonment of modern industrial society for a more agrarian self-sufficiency of diffused populations *(6)*, but many authors dealt with particular problems of limited mineral resources, water and air pollution and recoverable materials from wastes, and thus entered the professional sphere of the sanitary (public health) engineer.

This period also saw a decline in the number of applications to study engineering (in western society), resulting from a disenchantment with technology, which young people saw as the cause of this plundering of resources. To combat this view, many engineering courses included such subjects as pollution control technology and "the engineer in society". Fortunately, most engineering educators maintained a sound body of instruction based on the required engineering disciplines which produce competent, forward-looking designers and constructors. To these core disciplines were added optional subjects which broadened the engineers' perspectives of their work. A few attempts were made to produce environmental specialists, some based on biological sciences or geography and occasionally on engineering. It seems that very few employment opportunities arose for such graduates, industry and government generally showing a marked preference for traditionally trained engineers (civil, mechanical, chemical), with added specializations in environmental matters. The other factor which led to the decline in employment opportunities for environmental specialists was the oil crisis of the mid-1970s.

2.2 The oil crisis

The rapid change in Middle East oil prices and the emergence of OPEC in the mid-1970s as a power to be reckoned with changed the industrial world's attitude to energy almost overnight. Protection of the environment became a luxury compared with the necessity of energy conservation. Resources in teaching and research were switched from pollution problems to energy exploitation. Engineers who may have concerned themselves with oil pollution of the sea and coastline found themselves suddenly changing to marine technology of offshore structures for oil exploration and exploitation. This changed the emphasis of much technology, although certain links between the environment and energy were strengthened, e.g. methane production from sewage sludge, nuclear power production, and waste effluents from coal-to-oil conversion.

2.3 Microchemical contaminants

Proceeding in parallel with the environmental revolution, and sometimes being fed by it, has been a growing concern with microchemical contaminants or micropollutants. The water engineer had been traditionally concerned with substances measured at the milligramme per litre (or part per million) concentration level, e.g. residual chlorine at 0.5 mg/l, fluoride at 1.0 mg/l, nitrate nitrogen at 10 mg/l. Now, standards are being advised at the microgramme per litre level, such as lead at 50μg/l, mercury at 2μg/l, lindane at 4μg/l, heptachlor at 0.1μg/l and total trihalomethanes at 100μg/l.

These new standards are based on the perceptions that (*a*) industrial or agricultural operations are releasing such substances (and that they may be modified into potentially more dangerous forms, e.g. the microbial methylation of mercury, and the chlorination of hydrocarbons); (*b*) the micropollutants may have human toxicological effects (including mutagenic and carcinogenic effects); and (*c*) the chemist has the ability to measure the micropollutant concentrations. Health hazards from new environmental pollutants in air, water, soil and the biosphere were assessed by a WHO study group in 1976 *(7)*.

Fashions come and go in such concern for micropollutants, and technology can too easily be driven into providing expensive control and treatment methods which may not be justified in the long term. Engineering hardware takes longer to develop and lasts longer (using capital and interest) than microchemical analysis. This slower and more costly response in engineering terms must be safeguarded from purely temporary influences, and therefore engineers require education in the appraisal and significance of displays of concern for the microchemical environment.

Public awareness of microchemical dangers normally remains low, but accidents such as that at the nuclear power reactor at Three Mile Island, the spillage of pesticide into the Rhine and the dioxin escape at Seveso suddenly bring pressure to bear for some form of control. The engineer, among others, must respond to such public concern, but in an informed and balanced way, because panic legislation can be modified or rescinded and microchemical analysis can be reappraised, but engineering hardware can stand as a monument to folly if it was designed and constructed in unnecessary haste.

2.4 Sanitary (public health) engineering

In the midst of all this pressure from environmentalists, energy conservationists and micropollutant experts, the sanitary (public health) engineer has had to continue his practical role of locating, designing, constructing and operating engineering works which will safeguard or improve the health of the public. This has involved the traditional areas of responsibility in water and wastewater, air pollution and solid waste management, together with a growing role in noise control. The public health content of these areas has been intensified due to the new concern with the environmental domain, and has resulted in reappraisals of existing technology (such as the role of chlorine in the formation of trihalomethanes and alternatives for disinfection) and consideration of newer technologies (e.g. reverse osmosis).

3. Biotechnology

Biochemical engineering has existed for many years as an educational discipline that arose from traditional industries concerned with food processing, fermentation and brewing which relied on microorganisms to effect some of the conversions in the manufacturing processes. To these were added developments in the pharmaceutical industry mainly due to antibiotics production, and biochemical engineering became an area associated with chemical engineering, with special requirements of feedstock, reactor design, sterile and monoculture conditions. Occasionally, biochemical engineering acknowledged the presence of sanitary (public health) engineering, but usually when a special industrial waste arising from the biochemical industries had to be treated.

Recently, a new impetus has been given to the use of microorganisms to produce industrially useful products. Some of these are fine chemicals and pharmaceuticals such as specialized enzymes; others are animal food such as single-cell protein, and others are biomass productions which may be used, for example, as an energy source. This newly emerged biotechnology has attracted industrial and governmental interest, and funds for education and research are now flowing in many cases towards the universities. Its associated subject of genetic engineering offers great potential for the manipulation of microorganisms for specific biochemical processes. This biotechnology is undoubtedly expensive, with very exacting requirements for its process design, and mainly concerns itself with products of very high market value.

Yet it seems that quality and sophistication are not enough. Some advocates of biotechnology have referred to the large existing operations of biological treatment of wastewater and claimed that they are part of biotechnology. This adds scale to biotechnology's importance, because undoubtedly the tonnages of product — purified effluent — exceed by far any chemical or biochemical engineering production process. However, the enthusiasm of biotechnologists diminishes when they realize the extremely low operating costs per tonne for what is usually a throw-away product, so it does not seem likely that biotechnology will embrace biological wastewater treatment in a very committed manner, although it may insist that it is part of the biotechnology discipline.

This means that sanitary (public health) engineers are not likely to find biological wastewater treatment taken over by biotechnologists, but the advent of biotechnology cannot for that reason be ignored. There is some evidence that students of biotechnology (and their teachers) are interested in learning about biological wastewater treatment and the disposal of solid organic wastes. The sanitary (public health) engineer will want to know what types of waste (liquid and solid) are likely to be generated by biotechnology industries; he may learn something of reactor design and operation for microbiological processes; he may find applications of genetic engineering of microbes to special waste treatment problems; he may have to be aware of the hazards of release of genetically manipulated microorganisms into the environment via waste materials or by accident.

Later, reference will be made to an undergraduate engineering course where civil (sanitary–public health) engineers, chemical engineers and biochemical engineers (biotechnologists) study, and are examined, together.

4. The European context

4.1 North–south differences

The European Region of WHO is not homogeneous; it divides in several different ways: culturally, politically, commercially, linguistically and in climate. In terms of sanitary (public health) engineering, the broad division is between north and south. The north is characterized by an industrial society with a long history of public water supplies, urban sanitation, highly developed waste disposal systems and integrated control over pollution problems. In the south, reliable water supplies are not yet available to all communities (nowhere near approaching the 99% + of the populations which are served by public water supplies in northern European countries). Sanitation in the south has not generally kept pace with urban growth. Air pollution control has lower priority in the south than in the north; solid waste collection and disposal is less firmly established in the south. The contrasts between such cities as Istanbul and Rotterdam, both large city ports, or Athens and Stockholm, both capitals near the sea, or a rural area in southern Portugal with a rural area in southern England, exemplify these north–south differences.

It follows that the European sanitary (public health) engineer cannot limit his education only to problems of modern industrial societies of the northern European type. The recent (1978) WHO seminar on environmental health impact assessment *(8)* discussed the emerging problems of environmental changes and their health implications in a general way, but it was the case studies from France, the United Kingdom, Czechoslovakia, Greece and Yugoslavia which revealed the difference in emphasis. The French study described an industrial complex including petrochemical industries. The United Kingdom example dealt with nuclear energy and with oil-related development. Czechoslovakian experience in intensive farming was described. In contrast, the Greek experience with the liquid wastes of Athens and the resulting pollution of the nearby coastal seawaters was recounted. The Yugoslav study, however, concentrated on another typically southern European problem: the tourist development of coastal areas.

The problems of tourist areas were discussed in detail at another WHO meeting, again in 1978, on environmental sanitation in European tourist areas *(9)*. The report of this meeting dealt mainly with the coastal regions, particularly the Mediterranean basin, but it also referred to the special problems of sanitation and pollution control in mountain resorts, principally for winter sports. These tourist pressures are seasonal and may be expected to recur annually, so engineering investment should be worthwhile even if the design calls for intermittent, but high-intensity, operation. Another related problem, not directly referred to in the report, is that of near-singular events, such as a special festival, the Olympic Games or World Cup football matches. These bring intense, short-term demands on water,

sanitation and health facilities (among others, for hotels, transport, etc.) and are likely to be unique. Some more package-type, temporary design of facilities is required which the engineer must treat in a very different way to a permanent installation.

4.2 Overseas work

European influence in developing countries is strong, particularly in technology. The cultural and linguistic associations of the British Commonwealth and the former French Empire maintain links in education, standards and practices. The bilateral agreements in culture and trade between various European and developing countries often result in transfer of technology. The World Bank and other international agencies (including WHO) often proffer advice, design and supervision of engineering works by Europeans, and international tendering for the supply and construction of new works and equipment usually involves European companies *(10)*.

The International Drinking Water Supply and Sanitation Decade has emphasized international collaboration in sanitary (public health) engineering and there is a steady demand for well qualified engineers from Europe and elsewhere to advise and work in developing countries. This means that the education of engineers cannot neglect the traditional areas of public health engineering: epidemiology of water-related diseases, parasitology, vector control, rural sanitation and waste disposal, as well as the significance of water resource development in tropical areas.

As a number of engineers from developing countries come to Europe to study (at the postgraduate international courses in Delft, Netherlands, for example), it may be argued that courses of study for tropical sanitary (public health) engineering should be arranged. These would then operate exclusively for those from tropical developing countries and Europeans who intend to work in them. This would be a false provision if it were to be intended for young engineers undergoing their first university-level education. It would specialize them, on the one hand, yet deny them the intellectual stimulus of dealing with the problems of modern sophisticated societies, on the other. Also, it would assume that European engineers would know, or have to decide in advance, that they were going to work for a significant period in a developing country.

It may be better to limit sanitary (public health) engineering education in Europe to a largely nontropical content and deal with the problems of developing countries in a postgraduate context, possibly as a series of intensive short courses such as those organized at the Loughborough University of Technology in the United Kingdom.

5. Engineering education

5.1 General

It is difficult to generalize about engineering education in Europe, as there are several different systems currently operating. It seems that a general education provides a background in a wide range of subjects for students up to the age of 18. After that, engineering students engage in studies at

universities, polytechnics or special institutes, and some practical training is included in these studies or follows them after academic work is concluded. The overall result is that, after a total of about 5–8 years of academic and practical education, the engineer is qualified to practise and take responsibility for design and construction. This leads to the designation Chartered Engineer, Ir., Dipl. Ing., etc. The patterns within each country seem much the same, whether the engineer is civil, mechanical, electrical, electronic, chemical, aeronautical, naval, etc.

5.2 The secondary-school basis

Secondary schooling, occupying the pre-university years up to the age of 18, usually provides a broad basis in humanities (literature, languages, history, geography, philosophy, art and world affairs) and in sciences (mathematics, chemistry, physics, biology, and technical sciences such as handicraft, technical drawing).

It is the sciences, particularly the physical sciences of mathematics, chemistry and physics, that form the basis of further education in engineering. Generally speaking, engineering students are not so well acquainted with biological sciences, and this becomes a handicap for those who progress through civil engineering to sanitary (public health) engineering.

5.3 Civil engineering courses

Most sanitary (public health) engineers are educated initially as civil engineers, because of the historical connections between the work of the civil engineer and the design, construction and operation of municipal engineering works, including water supply, drainage, sanitation and collection and disposal of domestic refuse.

As a consequence, on the basis of mathematics, chemistry and physics learned at school, the civil engineer is educated in further mathematics, statistics and computing, surveying, materials, statistics and dynamics, structural and soil mechanics, process (kinetics), electrical science, fluid mechanics, modelling (physical and computer) and optimization techniques. Associated with these studies are laboratory and design courses. In addition to these predominantly physical subjects, there are often other topics, some of which are optional. These include management, law, building science (services engineering for heating, ventilation, lighting, etc.), economics, geology, transportation. Very rarely is a civil engineer instructed in any further biology or biochemistry, except if his subjects include sanitary (public health) engineering.

Sanitary (public health) engineering is offered in some undergraduate courses, but usually only in the final year. Therefore, there has usually been a break of a few years since the student last encountered any biological subjects. It is necessary then to reacquaint the student with biological terms and their significance, to partially reorientate his mind from the strongly physical, and rather deterministic, training he has received as an engineer. The biology must, then, be focused on those aspects that are significant in the domains of public health which are the province of the sanitary engineer.

Frequently, sanitary (public health) engineering courses are postgraduate, typically one year in duration. In some cases, they follow directly from basic education in civil engineering. In others, they are organized for engineers with several years of experience in the field, as exemplified by the international courses at Delft, Netherlands.

It is significant that among those who study and practise sanitary (public health) engineering are an increasing number of chemical, and latterly biochemical, engineers. Such engineers are already well acquainted with process and reactor design and the chemical changes which take place in purification operations. Usually, they are less familiar with the scales and economic values used in municipal enterprises and the public responsibility aspects of sanitary (public health) engineering. Although their knowledge of process biochemistry is usually far superior to that of the civil sanitary engineer, their knowledge of the health biological consequences is no better developed.

6. Public health

6.1 Limits of application

From the background described above, it is evident that the public health and biological components of the training curricula of sanitary (public health) engineers fall into three general areas: traditional public health and hygiene relating to water supply, sanitation and solid waste disposal, public health aspects of southern European areas, and public health aspects of more recently discovered significance in highly industrialized societies (northern Europe).

These have to be viewed in the context of the engineer's responsibility: to design, construct and operate hardware, particularly in the municipal engineering field, so that it either causes no danger or reduces or eliminates danger to the health of the public. This does not, then, confuse the work of the engineer with that, for example, of the medical doctor, the factory inspector or the monitoring chemist, although he may well work in co-operation with all of these. It follows that such an engineer is not involved directly with industrial hygiene, occupational health or safety, which are the domains of other professionals. The word "hardware" is general, referring to constructed items such as tanks, pipes, chimneys, dams, embankments, filters, etc. The engineer may also be responsible for software such as operating regimes and control strategies, but these should be related to hardware and not to areas such as legislative control or political decision. Those are important, and the engineer may give his advice as an expert, but legislation should be drafted and enacted by parliament, political decisions made by politicians, economic strategies by economists, and so on.

6.2 Traditional public health and hygiene

The historical development of public health in the nineteenth century and a review of waterborne and vector-transmitted diseases can be combined with an appreciation of current conditions in tropical developing countries. It follows that the following topics should be taught:

(*a*) public health and hygiene: historical development;

(*b*) microbiology: classification of microorganisms, growth conditions, symbiotic and host–predator relationships, ecological factors, hot climates;

(*c*) epidemiology: human health;

(*d*) water-related infections: classification, waterborne diseases, water-related diseases, water-based diseases;

(*e*) water-related insect vectors of diseases;

(*f*) diseases caused by defective sanitation;

(*g*) irrigation schemes and man-made lakes: health implications; health protection for staff and workers; displaced people, immigrants; vector-borne diseases;

(*h*) entomology and helminthology of sewage treatment, sanitation and waste disposal: flies, other insects, helminth biology and transmission, effects of sewage treatment;

(*i*) agricultural use of excreta, sewage, reclaimed wastewater, compost in relation to health hazards;

(*j*) solid wastes: vector control (flies, rodents, dogs, etc.), human scavengers, leachates, fire hazards;

(*k*) sociocultural aspects of health control in urban and rural communities of developing countries.

These aspects of public health are dominated by the possible biological hazards. Although there are possible chemical dangers (e.g. high-fluoride water), these are not so common as the many biological factors: widespread contamination, endemic diseases, insect and other vectors and high temperatures associated with tropical developing countries.

Much of the foregoing list appears in greater detail in the book "Water, wastes and health in hot climates", published in 1977 *(11)*.

6.3 Public health in southern Europe

The situation in southern Europe referred to earlier (4.1) lies somewhere between the tropical developing country and a highly industrialized community as far as public health is concerned. Summer temperatures are high, frequently approaching 35 °C, insects breed rapidly and sanitation is not fully developed. Yet there is a technical and public health framework which can react to a potentially dangerous health situation. In general, the provision of water supply is better developed than that of adequate sanitation facilities.

Consequently, the principal topics to be taught are:

(*a*) public health and hygiene: historical development;

(*b*) microbiology: classification of microorganisms, growth conditions, symbiotic and host-predator relationships, ecological factors, temperature effects;

(*c*) epidemiology: human health, biostatistics;

(*d*) parasitology;

(*e*) vector agents of disease;

(*f*) diseases of defective sanitation;

(*g*) solid wastes: vector control (flies, rodents, dogs, etc.), public access, leachates, fire hazards, uncontrolled dumping of dangerous chemicals;

(*h*) agricultural use of excreta, sewage, reclaimed wastewater, compost in relation to health hazards;

(*i*) uncontrolled industrial development: pollution of rivers, lakes, sea, air and associated health hazards;

(*j*) tourism: water and sanitation for tourist hotel complexes, caravan parks and camps, beach resorts, mountain resorts, bathing-beach standards;

(*k*) health considerations of migrant populations.

A book which appears to deal directly with such a southern European situation is the WHO publication entitled "An environmental sanitation plan for the Mediterranean seaboard" *(12)*. Also, some aspects are touched upon in "Environmental sanitation in European tourist areas" *(9)* and in a chapter on recreation areas and temporary residences in the book by Salvato *(13)*.

6.4 Public health in northern Europe

The northern European requirements for a public health element in sanitary (public health) engineering education are complicated by the sophistication of an industrial society, with its integrated technical/commercial/social structure, the highly linked aspects of political control (e.g. the many government ministries involved in environmental affairs at national, provincial and local levels), and the high degree of public awareness, to which powerful news media contribute.

From the scientific, medical and technical point of view, it is possible to identify five areas of hazard to the health of the public; these are microbiological, inorganic chemical, organic chemical, radiation and noise. They

may operate in the water, air, soil or ambient contexts. The special cases of food and beverages, occupational hygiene and safety are excluded, for although they may affect the overall exposure of any individual, they do not affect the public in the sphere of the professional activities of the sanitary (public health) engineer.

Before embarking on instruction in these five public health areas, they must be placed in the context of the exposure of the public to risk and the methods of risk assessment. This would require some instruction in:

- man and environmental exposure; physiological basis of health hazards from ingestion, inhalation, radiation and excessive noise; toxicology;
- biostatistics and epidemiology.

In addition, some general instruction has to be given, reinforcing existing knowledge in basic science, namely in:

- microbiology;
- chemistry, inorganic and organic compounds and their reactions;
- physics, including radiation and acoustics, aerosols and meteorology.

Then it should be possible to proceed to some instruction in the five areas. One possible approach is to take case studies of particular contemporary problems and from these develop a philosophy of approach by the sanitary (public health) engineer in his work of design, construction and operation. The following are examples of contemporary topics for student seminars and are not meant to be exhaustive.

(*a*) *Microbiological hazards.* These would include human viruses in water, wastewater and soil *(14)*, droplet infection in aerosols (e.g. near sewage aeration tanks), legionnaires' disease, health aspects of treated sewage reuse *(15)*, transfer of microorganisms by air travel, genetically manipulated bacteria.

(*b*) *Inorganic chemical hazards.* Lead (in water from plumbing, in air from vehicle emissions, in soil from atmospheric fall-out or waste disposal), heavy metals in sludges, mercury and its methylation, soft water and cardiovascular disease, nitrates in water, nitrogen compounds in the atmosphere, acid rain, asbestos (and its use in construction, pipes, etc.), ozone compounds, toxic solid wastes, aerosol particles.

(*c*) *Organic chemical hazards.* Pesticide residues in water and soil, polycyclic aromatic hydrocarbons in air and water, PCBs, detergent residues, chlorinated hydrocarbons, trihalomethanes, synthetic polyelectrolytes and their monomers in water treatment, aerosol-spray gases, toxic sludges and semi-solid wastes.

(*d*) *Radiation hazards.* Transport and disposal of radioactive wastes, siting of nuclear power plants, contamination from nuclear accidents.

(*e*) *Noise hazards.* Hearing losses over the frequency range: temporary and permanent; acoustic baffling: personal, structural (sound insulation, double glazing, etc.) and environmental (embankments, trees, fences, etc.); noise hazards from construction, road traffic, aircraft, entertainment (discothèques, pop concerts).

Recent commentaries on some of these contemporary problems appear in works by van Lelyveld & Zoeteman *(16)* and Chanlett *(17)*.

7. Problem-solving

The engineer cannot solve his practical problems in isolation. In a structural–technical sense, the design of the whole is not just a collection of the designs of parts, because of structural interactions. The same is true of designs in the sanitary (public health) engineering domain. The site location, the supply and disposal of the water, wastewater or solid wastes, the flow conditions, the structural conditions, the process requirements and the public health aspects must be integrated.

In addition, the constructed and operated works do not function in isolation: they must fit the economic framework of the community, they provide employment, they generate secondary activities (e.g. transport, parking, canteen facilities, sports and recreation for the workforce, housing). Also, in modern developed communities, there is an awareness, caused partly by the environmental revolution, of public health facilities. This awareness can be a matter of local civic pride or strong local criticism.

It is essential, therefore, that the sanitary (public health) engineer, in his education and training, can exercise this integrative function. The local community is more likely to react and demand action if aspects of public health are posing hazards than to be concerned if the flow in a process unit is unstable or a control valve is malfunctioning. In either case, the engineer's response may have to be a hardware adjustment to rectify the problem, but his knowledge of public health aspects will enable him to evalute the public concern and take appropriate action. In the United Kingdom, for example, this part of an engineer's training is ensured by testing his understanding of the relationship between the engineer and society before he finally qualifies as a chartered engineer.

8. Summary and discussion topics

8.1 Summary

(1) The 1970 WHO publication "The education and training of engineers for environmental health" provided a very broad view of the components concerning the environment to be included in engineering curricula. The all-embracing nature of its proposals may have deterred educators by the demands for teachers and teaching. Also, the "environmental engineer" who would be produced may not yet have a clearly defined employment opportunity.

(2) Since the 1967 Expert Committee's meeting and the 1970 WHO publication, some developments have affected engineering education and

research. Principally, these have been the environmental revolution with its associated public awareness, the world energy crisis and economic recession. The first focused attention on environmental matters, the others deflected attention away from what industry and some governments regarded as a luxury (concern for the environment).

(3) The International Drinking Water Supply and Sanitation Decade has increased the general awareness of public health problems associated with water in developing countries.

(4) The role of the sanitary (public health) engineer has continued to be important in Europe (and elsewhere) in the traditional areas of water supply, wastewater disposal, air pollution control and solid waste disposal.

(5) Chemical and biochemical engineers have shown an increasing interest in these environmental matters, some of this interest being stimulated by the emergence of biotechnology and genetic engineering of microorganisms.

(6) There still appears to be a need for civil engineers (and possibly chemical engineers) trained in their traditional disciplines, including sanitary (public health) engineering. However, new awareness of requirements in tropical developing countries, southern Europe and northern Europe requires a reappraisal of the public health component of education.

(7) The tropical developing country aspect of public health includes hygiene, microbiology, epidemiology, diseases relating to water, defective sanitation, insects and helminths, agriculture, solid wastes and sociocultural factors.

(8) The southern European aspect includes hygiene, microbiology, epidemiology, human health, parasitology, vector agents of disease, sanitation, solid wastes, agriculture, industrial pollution, tourism and migration.

(9) The northern European aspects require a more integrated appraisal of environment, toxicology, biostatistics and epidemiology. A stress on microbiology, chemistry and physics should lead to studies in contemporary microbiological hazards, inorganic and organic chemical (including microchemical) hazards, radiation hazards and noise hazards.

8.2 Discussion topics

(1) Has there been a change in the requirement of the public health component of sanitary (public health) engineers' training curricula in the past 15 years?

(2) If yes, what new factors have affected this requirement?

(3) What new knowledge is now required?

(4) Are the traditional subjects of chemistry, microbiology, biostatistics, epidemiology, parasitology and entomology still appropriate?

(5) Is an alternative structure based on (*a*) water contact, air contact, soil and ambient conditions, or (*b*) biological, inorganic chemical, organic chemical, radiation and noise hazards, more appropriate?

(6) Can any parts of traditional curricula now be omitted?

(7) If no, how can the new knowledge be incorporated into the already crowded curricula of engineering education?

(8) What new laboratory or field study provisions will be required?

(9) Should all sanitary (public health) engineers be trained to the same level of competence in public health aspects?

(10) Are there different requirements for tropical, southern European and northern European components of public health training?

(11) If yes, should these represent options in sanitary (public health) engineering training curricula?

(12) Who will train the teachers?

(13) Is research to be reoriented as a result of changes in the past 15 years?

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Appendix 1

RECOMMENDATIONS OF THE WHO EXPERT COMMITTEE ON THE EDUCATION OF ENGINEERS IN ENVIRONMENTAL HEALTH, 1967[a]

1. Educational programmes in environmental health engineering, where they do not now exist, should be made available throughout the world, either nationally or regionally.

2. Many organizations — international, national and private — are concerned with various aspects of practice, research and education in environmental health engineering. It is in the interest of both economy and efficiency that such agencies cooperate, e.g. in exchange of information, support for educational programmes, provision of fellowships and programme planning.

3. Where educational programmes are established, it is essential that such projects be long-range activities that will continue on a firm basis after the termination of outside assistance. Use should be made of highly qualified, capable and adaptable personnel for consultation, particularly in the early stages of development. It is important that research, key personnel and planning be of the highest calibre. The production of key personnel is essential in educational and training programmes, since it is on such personnel that future education and training will depend.

4. Regional and national cooperation is urgently recommended for countries developing university-level programmes in environmental health engineering. Cooperative action by international and other agencies can play an important role in promoting such regional cooperation. The creation of educational and training institutions for technicians should be encouraged in every country.

5. It is recommended that regional meetings of environmental health engineering teachers be held periodically. Such meetings can be invaluable as a means of exchanging information and solving common problems.

6. In view of the importance of environmental health engineering concepts for all branches of engineering, architecture and planning, they should be introduced, wherever possible, into educational programmes in such fields.

7. An international directory of institutions giving training in environmental health engineering should be prepared.

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[a] WHO Technical Report Series, No. 376, 1967 (*The education of engineers in environmental health*: report of a WHO Expert Committee).

Annex 2

PUBLIC HEALTH AND SANITARY ENGINEERING EDUCATION

Professor M.S. Hilbert[a]

Introduction

In order to address the curriculum requirements in the training programmes of professionals, it is essential to define, as clearly as possible, the role and function envisioned for the graduates. A discussion of the desirable public health components of sanitary engineering education should start with a number of definitions related to the fields of public health and sanitary engineering. It must be assumed that the graduates will be expected to apply the practice of engineering to those aspects of the environment which may, in one way or another, affect health.

A broad definition of "environmental health" was adopted by the legislative body of the State of Michigan, USA, in 1978 as follows: "Environmental health means the area of activity which deals with the protection of human health through the management, control, and prevention of environmental factors which may adversely affect the health of individuals. This activity is concerned with the existence of substances, conditions, or facilities in quantities, of characteristics, and under conditions, circumstances, or durations which are or can be injurious to human health".

In discussing the public health components of sanitary engineering education, this defintion of environmental health could serve as the basis for considering desirable curricula development.

Webster's Dictionary defines sanitary engineering as a branch of civil engineering dealing with water supply, sewage and waste disposal and other sanitary problems, while a civil engineer is defined as one who is responsible for the design and construction of fixed public works, highways, bridges, waterworks, canals, harbours and railroads.

Engineers conceive, design and supervise construction of various types of facility. The field of engineering is considered an applied science concerned with the utilization of inorganic products of earth, properties of matter, sources of power and physical forces for supplying human needs in the form of structures, machines, manufactured products and other productive works.

In 1980, the US Engineers' Council for Professional Development adopted the definition of engineering as the profession in which the knowledge of mathematical and natural sciences gained by study, experience and practice is applied with judgement to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.

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During the past two decades there have been increasing efforts to expand the role of the sanitary engineer in order to address the ever-increasing problems of the environment which affect the health of individuals. In the United States, the term "sanitary engineering" is being replaced by the term "environmental engineering" to reflect the broader impact of engineering efforts on the control and prevention of environmental hazards. Environmental engineering has been defined as that branch of engineering which is concerned with (*a*) the protection of human populations from the effects of adverse environmental factors, (*b*) the protection of environments, both local and global, from the potentially deleterious effects of human activities, and (*c*) the improvement of environmental quality for human health and wellbeing.

The practice of environmental engineering covers the broad scope of environmental areas of specialization including the traditional fields of sanitary engineering, industrial hygiene engineering, air pollution control engineering and radiation and hazard control engineering.

Environmental engineering is, in fact, an interdisciplinary science based on the engineering and applied sciences for which human health and wellbeing is the principal focus. Environmental engineering requires knowledge in the technical fields of air, water, wastewater, solid waste, industrial hygiene, radiation control and other areas of specialization which require engineering consideration of environmental factors affecting human health and wellbeing. In addition, the application of these technical fields to societal needs requires an understanding and knowledge in the fields of law, economics, finance, public administration, planning and other social sciences.

Curricula

In the development of an educational programme of study, it is essential to state the objectives in behavioural terms. It is desirable to state what the graduate of the programme is expected to be able to achieve.

If public health and environmental health components are to be incorporated in the education of sanitary engineers, it is necessary to assess the current demand for the services of engineers with the proposed training. The availability of individuals with specialized environmental engineering training which was not previously provided may cause employers to create new positions. On the other hand, if the training programme is expanded to cover new areas of environmental concern at the expense of traditional engineering education, graduates may find it difficult to convince prospective employers of the need for their broad expertise.

If the word "engineering" is part of the degree title, it is essential that the curricula provide the undergraduate student with a sound educational programme of study which should be directed toward the development of the ability to apply pertinent knowledge to the identification and the engineering solution of problems in the several areas of engineering specialization. It is essential to educate all students in the fundamental fields of engineering knowledge in order that they will be able to deal with change.

It would be expected that all students should have a basic undergraduate engineering education which should include at least:

— humanities and social science

— mathematics (through differential equations)

— basic sciences: physics, chemistry, biological sciences

— engineering sciences

— design synthesis and systems.

During the undergraduate programme the students should be exposed to the several areas of specialization in the field of environmental engineering in addition to the more traditional sanitary engineering area of specialization. This could include an introduction to problems of industrial hygiene engineering, air resource management, solid waste engineering including hazardous waste problems, radiation control and urban development.

The very nature of the wide range of environmental problems which require engineering solutions poses the problem of breadth as well as depth in the curriculum for environmental engineers. The areas of study include climatological, biological, physical and chemical sciences as well as the social, political, economic and cultural aspects of the engineering approach to problem solution.

The societal needs for environmental engineering cannot be met by engineering generalists who have completed only introductory courses in the broad fields mentioned above. There may be an administrative need for a number of such generalists, but the engineering solution to the vast array of environmental problems demands the training of specialists with in-depth course work in the area of specialization.

It is apparent that, in order to accomplish the degree of specialization required, the several areas of specialization should be added to basic undergraduate engineering education through programmes of graduate study in those areas of specialization. Thus, the student could select the area of specialization which would build on basic sanitary engineering education.

It is not expected that all educational institutions will have the resources required to offer training in all areas of specialization. Some institutions may find their strength in one area, while others will offer programmes of study in other areas.

The following graduate programme content for four areas of specialization was suggested at the 1980 Conference on Environmental Engineering Education, held in Toronto, Canada.[a]

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[a] **Patterson, J.W. & Minear, R.A.** *Proceedings, Fourth Conference on Environmental Education.* Association of Environmental Engineering Professors, 1980, p. 116.

1. *Air quality engineering — Master's programme*

Fundamentals of air pollution: air pollution dynamics, source factors

Atmospheric sampling and analysis: chemistry of pollutants, sampling and analysis, photochemistry

Meteorology: properties and dynamics of the atmosphere, atmospheric transport and diffusion

Physics: aerosol science and technology, including optical properties of atmospheric aerosols

Air pollution control systems, air pollution management

Applied mathematics: advanced statistics, mathematical models

Biological aspects of air pollution: cell and human biology, effects on vegetation, animals and humans, air microbiology

Thesis options

2. *Industrial hygiene engineering — Master's programme*

Applied mathematics: biostatistics, mathematical modelling

Occupational health: audiology, toxicology, radiology, physiology, public health, epidemiology, and safety engineering

Thesis option

3. *Solid wastes management — Master's programme*

Resource recovery: conservation and reuse, recycle economics

Microbiology of water, air and soil: applications to environmental pollution control

Analytical analysis: (physical, chemical, and biological) of water, wastewater, air and solid wastes

Solid wastes control and management: characterization, production, storage, collection and transport of solid wastes; alternative disposal methods, design principles and environmental impact; economics of waste management

Combustion engineering: combustion fundamentals, incinerator design

Thesis option

4. *Water quality engineering — Master's programme*

General water quality and analysis: sanitary analysis, applied organic and physical chemistry, applied microbiology

Applied mathematics: mathematical models, environmental statistics, optimization techniques

Unit operations and design: design of treatment facilities; chemical, physical and biological systems

Water resources systems analysis, simulation analysis

Thesis option

In all programmes emphasis should be placed on the engineering design component. It is also suggested that the need for communication skills should not be neglected. The above components in the four areas of specialization were offered as a guide for programme development with the full expectation that programmes at various institutions would vary in course content, emphasis, mix of courses and depth of coverage.

Graduate programmes in the United States vary from one institution to another. Some emphasize one or two areas of specialization, while others provide graduate educational opportunities in a wide variety of environmental areas. The Association of Environmental Engineering Professors has published a Register of Environmental Engineering Graduate Programs for the United States.[a] Although no specific programmes of study have been published, the Register contains a list of courses offered, from which the graduate programmes of study are developed. (Graduate courses offered in environmental engineering by three selected institutions in the USA are listed in Part III.) These course lists demonstrate the scope of subjects offered, the tendency towards specialization in some schools, a more general approach in others and, above all, the lack of uniformity among the various graduate programmes.

The scope of environmental health and the wide range of subjects which may require an engineer's professional involvement are indicated below.

Scope of environmental health

1. *Accident prevention*

   Home accidents

2. *Air pollution*

3. *Animal diseases transmissible to man*

   Rabies control
   Brucellosis control
   Tuberculosis control
   Aviary inspection

[a] **Vesilind, P.A. & Mineur, R.A.** *Register of environmental engineering graduate programs*, Association of Environmental Engineering Professors. Woburn, MA, Ann Arbor Science Publishers, 1981.

4. *Emergencies*

Civil defence
Epidemics
Fire, flood, drought

5. *Food establishments*

Restaurants
Taverns
Soda fountains
Bakeries
Grocery stores
Food-processing plants
Frozen-food lockers
Honey production and packing
Cider mills

6. *Housing*

Conservation
Rehabilitation
Clearance

7. *Industrial establishments*

General sanitation
Gases
Dusts
Fumes
Other industrial hazards

8. *Insect and rodent control*

Breeding places
Infestation
Control measures

9. *Meat*

Slaughterhouses
Meat inspection
Poultry inspection

10. *Milk*

Pasteurization plants
Milk products plants
Producer farms

11. *Noise*

12. *Public, quasi-public, recreational, business and commercial establishments*

Trailer parks
Hospitals
Sanatoriums
Nursing homes
Homes for the aged
Maternity homes
Country clubs
Hotels
Jails
Boarding homes
Day care centres
Nursery schools
Churches
Bowling-alleys
Roller-skating rinks
Theatres
Ball parks
Dance-halls

Clubs
Fairs
Carnivals, circuses and public exhibitions
Barber shops
Terminals
Tourist courts
Motels and cabin camps
Resorts
Camps
Recreational areas
Parks
Roadsides

13. *Radiation*

14. *Refuse and solid wastes*

Collection
Transportation
Place of disposal
Method of disposal
Areas served

15. *Schools and institutions*

Planning
Operation
Maintenance

16. *Sewerage and liquid wastes*

Sewerage systems
Promotion of sewer extensions
Treatment plants
Septic tanks
Privies
Stream pollution
Aid in development plans

17. *Subdivisions and plants*

Water supply
Sewage disposal
Drainage
Land development

18. *Swimming and bathing*

Public swimming-pools
Private swimming-pools
Bathing-places

19. *Water*

Municipal distribution
Promotion of water-main extensions
Source of supply
Treatment plants
Pressure problems
Semi-public supplies
Private supplies
Geological problems
Surface-water availability
Aid in development plans
Toxic and hazardous substances

Annex 3

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Sanitary engineering began to develop as a distinct discipline around the turn of the century, but it is still often regarded merely as a minor offshoot of civil engineering. Also known as public health engineering (in the United States) it covers all those fields where engineering activities are more efficient than medical action for dealing with public health problems. On the basis of this definition, sanitary engineering has sprung up in a multitude of ways and forms in different countries. This has created confusion about the discipline and difficulties in training people in it. Sanitary engineers are therefore in short supply in the European Region.

This book should dispel a lot of the confusion and help to increase the number of people training as sanitary engineers. Country by country it highlights the engineering courses available in the European Region that are directly related to human health. At present, training is available in two forms: as undergraduate courses with options related to public health, and as short postgraduate courses, one-year diplomas and Master's degrees. The book goes on to describe in detail the curricula of a number of representative courses in a cross-section of countries in Europe, plus three courses in the United States. It specifies those that cater particularly for developing countries and in which languages the tuition is given.

Ever since the 1950s the WHO Regional Office has promoted the concept of sanitary engineering. A historical survey of the development of sanitary engineering, its current scope and the training and tasks of sanitary engineers are given in a separate section. Most countries now have some form of sanitary engineering curriculum with a public health approach. But there is a tendency still for this approach to be ignored at the expense of civil engineering proper, or for the ecological approach to be preferred instead. This book emphasizes the importance of the public health approach to sanitary engineering. It should be an invaluable guide to present and future students of sanitary engineering, as well as to all those responsible for the curricular content of sanitary engineering courses.